

TABLE OF CONTENTS

AG.130 – INTRODUCTION TO AGRICULTURAL MECHANICS

130-A	Shop Cleaning and Tool Storage
130-B	Safety Practices in the Shop
130-C	Measuring
130-D	Drafting and Sketching
130-E	Tool Safety, Use and Identification
130-F	Tool Reconditioning and Maintenance
130-G	Plumbing and Pipe Fitting
130-H	Wood Working
130-I	Bill of Materials
130-J	Rope Work
130-K	Hot and Cold Metal Work
130-L	Fence Construction
130-M	Concrete
130-N	Fasteners
130-O	Painting, Brush & Spray Gun
130-P	Building Structures, Framing, and Rafter Cutting
130-Q	Introduction to Electricity
130-R	Electrical Wiring Practices
130-S	Electrical Motors
130-T	Servicing Small Engines
130-U	Surveying
130-V	Careers in Agricultural Mechanics
130-W	Introduction to Oxyacetylene Welding and Cutting Skills
130-X	Introduction to Arc Welding
130-Y	Projects

130A-1

SHOP CLEANING AND TOOL STORAGE

AG 130-A

UNIT OBJECTIVE

After completion of this unit, students will be able to identify the importance and scope of the agricultural mechanics industry in the United States, Idaho, and the local community. Students will learn importance of a clean shop and proper tool storage. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Store tools in their proper place being cabinets, tool boards or tool room.
2. Store equipment and materials properly.
3. Follow clean up assignments.
4. Clean shop properly as directed by the instructor.
5. Know procedures for repairing or replacing broken tools.

SHOP CLEANING AND TOOL STORAGE

A. Introduction:

The students should have a definite understanding of the requirements for a clean and orderly shop. All students should have a shop cleanup review before the first class laboratory exercise. A disorderly shop can lead to many unsafe conditions, which can result in accidents and injury. A clean shop can also reduce the costs to the department in the prevention of lost or damaged tools and equipment.

B. Purpose of maintaining a clean shop and storing tools correctly.

When the United States entered World War II the shipyards were under tremendous pressure to build ships as rapidly as possible. Each shift of workers had a cleanup crew that put tools away, swept the floors, and sent broken tools in for repair. When the next shift started everything was in place and ready to use. Much time was saved because people didn't have to wonder around finding tools and all tools were in usable condition. Today, modern factories (maybe because of OSHA) are very strict in clean-up and tool storage.

1. All students work together in maintaining the shop learning teamwork and cooperation.
2. The risk of safety hazards is reduced in a clean shop because obstacles and spills are removed.
3. Students learn the layout of the shop faster when required to restore the shop to its original order on a daily basis. The placement of all tools and equipment is also learned faster. Students will spend less time searching for tools and equipment when needed.
4. Tools can regularly be checked for damage if they are returned to their assigned storage point after each use. This also reduces the incidence of lost tools.
5. Students can find their projects quicker if they are stored neatly in an assigned place. Properly stored projects will not interfere with the safety of other shop users nor will they hinder the accessibility of other projects.

C. Shop requirements for an efficient cleaning and storage system, cabinets, tool boards, and tool rooms.

1. A tool board should be large enough to handle all of the hand tools used in the shop. A vertical board is recommended so all of the tools are visible at once and easily accessible.
2. The tool board or storage cabinet should have closing doors that can be locked for security.

3. The tools should be fitted so that each can hang individually when not in use. A system should be setup to store similar tools in the same sections to facilitate inventory checks. Nails and clips can be used to hang each tool.
4. Ideally, each tool is outlined, or silhouetted, so that each tool can be returned quickly to the correct spot. Missing tools are easily detected using this method.

D. Material Storage

1. Lumber, angle iron, steel rods, and scrap iron should be stored in vertical racks. Vertical racks facilitate both long and short items and utilize wall space better than most other material storage systems. The desired material can also be easily reached without removing too many additional materials.
2. Separate vertical racks should be used to store different types and widths of lumber and various metal materials.
3. Do not store materials past the horizontal stabilizer bars. The material will no longer be supported from falling and can cause serious injury.

E. Scrap Material

1. Separate bins should be supplied for scrap lumber and metal. These bins should be for material that cannot be reused. Reusable scraps should be stored in the vertical racks.
2. Never allow the scrap bins to overflow. Scrap material is a major source of clutter in many shops. It can become either a fire hazard or an accident risk if allowed to accumulate. Scrap material can often be sold and recycled. If not, it should be hauled to the dump on a regular basis.
3. Nails, staples, and other obstructions should be removed from scrap wood before it is placed in the scrap bin.
4. **HOT METAL MUST NEVER BE THROWN IN THE SCRAP BIN.** Burn injuries are common in many machine shops because students do not obey this rule. Hot metal also creates a fire hazard when improperly stored. All scrap metal bins should be marked with warnings to cool all metal before it is disposed.

F. Flammable Liquids

1. Flammable liquids--such as grease, oil, and solvents should be stored in special storage containers designed for this purpose. These storage containers are made of steel and are designed to close automatically in the presence of fire to prevent the spread of the fire.
2. Dirty rags are also a fire hazard in the shop. A metal container with a sealable lid should be provided to store all rags that have been exposed to grease, oil, or solvents.

3. Always store gasoline or rags that have been exposed to gasoline in a separate, well-ventilated area. Gasoline should never be stored in the shop due to its high combustibility.

G. Shop Cleaning Procedures

A well-organized and properly cleaned shop is the responsibility of every student in the class. The instructor should act only in a supervisory position once the students are oriented to the cleanup procedures. The cleaning procedure should follow a systematic approach. Some of the steps included in a thorough shop cleanup are as follows:

1. The teacher or appointed student signals for all work to cease at an appropriate interval before the end of class.
2. Each student cleans up his or her individual work area. Projects are properly stored and tools and equipment are returned to their proper places.
3. Solvents, grease, oil, paints, and other flammables are stored properly. Paintbrushes are cleaned and dried.
4. Scrap wood and metal are separated and placed in the appropriate waste bins. Scrap metal is cooled before being placed in the bin.
5. All spare metal and wood stock is returned to its appropriate rack.
6. All benches and machines are cleared with a brush. Dust, scraps, and waste are then swept towards the center of the aisle or floor. Assigned students use push brooms to clear the floor. All waste and trash is placed in the appropriate containers.
7. The teacher or appointed students check to make sure all of the tools and equipment has been returned to their appropriate places. All cleanup jobs are checked for completeness. No one leaves the shop until all jobs are done.
8. The tool cabinet and the material area are locked if a lock system is available.
9. Students wait in an orderly manner until dismissed by the instructor.

METHODS OF CLEANING

A. Methods of Cleaning

1. The all-pitch-in method involves trusting each student to clean up individual projects and contribute to the overall shop cleaning. No individual tasks are assigned. It is the responsibility of the entire class to appropriately finish the cleaning job and assure that all tools, material, and equipment are accounted for.

2. Assignment sheets can also be developed so that each student has an individual responsibility in the cleanup procedure each day. The advantage of this system is that each student can be singled out as responsible when a portion of the job is not completed. Students can also be graded for their cleanup procedures using this method.
3. Work teams can be developed in which each group is responsible for a portion of the duties. The advantage of this system is similar to that for the assignment sheet method.
4. A clean-up wheel method can be developed in which a wheel is divided into two separate wheels, one within the other. The outer wheel is immobile and has each duty listed. The inner wheel has the names of individuals or work groups on it. The inner wheel is spun to determine which duty will be performed that day. This method helps to motivate students to perform their chores and assures them of performing many different tasks instead of the same one over and over. This system may become time consuming since time must be spent every class period to spin the wheel in order to assign tasks.
5. Any system can be used effectively to keep a shop clean and orderly. The method used will vary depending on whether the students are graded on their cleanup procedures and the amount of time available each day for cleanup. All systems are equally effective as long as they include all the students in the process and the procedure follows a systematic approach.

ACTIVITY:

1. Take the students on a tour of the shop to point out each cleaning task and its purpose. Have a walk-through of the cleanup procedure during one class period.
2. Develop a point system so students can compete to win an award for their clean-up performance.
3. Use films and videos to point out the dangers of an unkempt shop.
4. If not available already, have the students develop and build different storage facilities for tools, materials, and waste products. Have a competition for the best design.

References:

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Phipps, Lloyd J., Miller, Glen M. (1998). AGRISCIENCE MECHANICS Danville, IL: Interstate Publishers, Inc.

Video References:

TOOL SECURITY AND MAINTENANCE Visual Education Productions, 1-800-235-4146 or www.cev-inc.com

UTAH SAFETY COUNCIL
5263 SOUTH 300 WEST, SUITE 201
SALT LAKE CITY, UTAH 84107
1-800-933-5943

Name _____

Date _____

SHOP CLEAN-UP

Answer the following questions with a short answer.

1. What is reduced in a clean shop because obstacles and spills are removed?

2. How often is the shop cleaned? _____

3. What reduces lost tools? _____

4. Does each tool have its' own place? ____ (yes / no)

5. What kind of tool storage does this shop have? _____

6. How many different storage areas does this shop have? _____

7. Where is each storage area located? (Some might have the same answer)

Steel? _____	Lumber? _____
Paint? _____	Scrap iron? _____
Engine Parts? _____	Oily rags? _____
Flammable Liquids? _____	Drill bits? _____
Brooms & Dust pans? _____	

8. Who is allowed to leave before the shop is cleaned? _____

9. What clean up method is used in this shop? _____

10. What part of the daily work grade is clean-up? _____

11. How many clean-up tools does this shop have?

Push Brooms? _____	Hand Brooms? _____
Dust Pans? _____	Trash Cans? _____

12. How often are the trashcans emptied? _____

13. When does clean-up start? _____

14. How long does clean-up take? _____

15. Who determines when the shop is clean and everyone is done? _____

Answers to the quiz

1. Safety Hazards
2. Every time it is used
3. Proper tool storage
4. Yes
5. Unknown
6. Unknown
7. Unknown
8. No One
9. Instructors' Choice
10. 20%(it should be)
11. Unknown
12. Once a week, more often if needed
13. At a certain time or when the instructor calls for it.
14. 5 - 7 minutes
15. Shop foreman or the instructor

130B-1

SAFETY PRACTICES IN THE SHOP

130-B

UNIT OBJECTIVE

After completion of this unit, students will be able to identify the importance of safety in the scope the agricultural mechanics industry in the United States, Idaho, and the local community. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Recognize and report hazardous situations.
2. Develop a proper attitude toward use of safety glasses and coveralls.
3. Develop a proper attitude toward work and avoid unsafe practices.
4. Practice all shop and equipment safety regulations.
5. Use a fire extinguisher properly.
6. Make and keep a folder containing Material Safety Data Sheets.

SAFETY PRACTICES IN THE SHOP

A. Introduction:

The most frequent cause of injuries and accidents in agriculture comes from the use of tools and machinery. Forty-four percent of all agriculture-related injuries occur while using farm machinery. Most of these accidents and injuries can be prevented through the development of safe work habits. The school agricultural mechanics shop is a good place to develop these safe habits.

B. Setting Up a Safe Agricultural Mechanics Shop

1. Install all machinery according to the manufacturer's directions.
2. Provide proper storage for all tools, equipment, material, scraps, flammable liquids, chemicals, and waste materials.
3. Keep all tools and equipment fitted and adjusted properly.
4. Remove all damaged tools and equipment from the shop or to a place where they cannot be accidentally picked up and used.
5. Provide proper orientation and practice to anyone who is going to use a particular piece of equipment.
6. Keep all moving parts of machinery properly shielded.
7. Keep working areas free of clutter, grease, dirt, and un-needed tools.
8. Avoid placing or storing objects where they might fall. Mark any area where an object may fall.
9. Protect the eyes, face, hands, and body with protective clothing and gear.
10. List safety precautions for all equipment and tools. (See safety sheets on pages 130B-14 through 130B-38)

C. Color marking systems are used to help shop users be alert to danger or hazards, to help people locate certain objects, or to help people react quickly during an emergency.

1. Red is used to signify danger. Red tape or paint should be placed around all equipment or areas that are to be identified as items of danger or emergency.
2. Orange is used to mark off areas where machine hazards are likely. This color is designated to mark off a safe working distance or an area in the flight path of moving parts.
3. Yellow is the color used to designate caution. Yellow and black stripes are often used to mark stairs and other stationary objects where a hazard may occur.
4. Green indicates the presence of safety equipment, safety areas, or first aid kits.

130B-3

5. Purple is used to signify radioactivity. This is not a problem in most agricultural mechanics shops, but some chemicals may be used where radioactive isotopes are present.
6. Gray is used to signify all work areas and usable machinery. Most shop floors are also painted gray because it is a restful color and it contrasts well with all other safety colors.
7. White, or white and black stripes are used to mark traffic pathways within the shop.
8. Blue is used as a background color if information is to be provided. Signs such as 'Out of Order' are written in white lettering on a blue background.

D. Protective clothing and gear can reduce the amount of injuries in the shop. Many accidents are caused by flying debris or contact with moving equipment. Thirty-six percent of all accidents in the shop occur to the arms and hands, ten percent occur to the head, and twenty-five percent of all injuries occur to the body. Proper use of protective clothing and gear can minimize or prevent these injuries.

1. Safety goggles or glasses should be worn in the shop at all times. They should be equipped with impact resistant lenses.
 - a. Tinted eye protection must be worn when welding. Separate tints are required for arc and gas welding in order to prevent burns to the eyes.
 - b. A face shield is required where flying debris is a problem. Grinders, planers, and power saws are examples of equipment that cause flying debris.
2. Headgear is used to restrain long hair and protect the head from falling objects. Woolen hats, headbands, and hairnets are acceptable to prevent long hair from coming in contact with moving parts, chemicals, or an open flame. Hard hats are required when falling objects may be a hazard.
3. Protective clothing is used to keep the body safe from injuries. Such clothing should fit properly and have no loose cuffs, strings, or ties that may get caught in machinery. The clothing should also be fire resistant and be tough enough to protect the body from scrapes and abrasions. Several types of protective clothing are available.

130B-4

- a. Coveralls are very popular because they cover the entire body as well as the legs and arms. Pockets are also an advantage of coveralls. Care should be taken to prevent any loose strings or cuffs on the coveralls. All buttons and zippers should have a protective flap and care should be taken to prevent ripped pockets from getting caught in moving machinery.
 - b. Aprons are often used to protect the body while welding. The leather apron prevents sparks from reaching the body. The disadvantage of aprons is that they require a string to tie them on, which is a hazard when working around moving parts. Aprons protect the body well, but do not provide protection to the arms and legs.
 - c. Shop coats are a good medium between coveralls and aprons. They protect both the body and arms and still have pockets to hold small tools. Zippers and buttons should have a protective flap to prevent electric shock or catching in moving parts. The shop coat is also the easiest body protection to put on and is often cheaper than coveralls.
4. Proper footwear is also important when working in the shop. Open toed footwear must NEVER be worn in the shop. Leather shoes with steel reinforced toes provide excellent protection. Leather is fire resistant and tough enough to resist the impact of many falling objects.
- a. Rubber boots are required when working in water or when using pesticides. These boots are also ideal when doing concrete work due to their resistance to water and the ease with which they can be cleaned.
5. Gloves can be both protective devices and safety hazards in the shop. Gloves are used to keep the hands warm and to protect them from abrasion, heat, and chemicals. Gloves are excellent protection when using tools that emit flying debris, such as grinders and chainsaws. Caution should be taken when wearing gloves around moving parts. Gloves can easily be pulled into the machines and serious injury can result. It is not advisable to wear gloves where the hands will come in close contact with the moving parts of a machine.
6. Ear plugs or earmuffs are ideal when working around noisy machinery. Some machines, such as planers, emit a very high pitched sound that can damage the inner ear if protection is not worn.
7. Masks and respirators should be worn when using machines that produce large amounts of dust. Application of chemicals also requires the use of a respirator.

E. Uncontrolled fires in an agricultural mechanics shop can spread very rapidly, causing death, serious injury, and the destruction of property and equipment. Since all shops contain flammable materials, students should be informed of the causes of fires, methods of preventing fires, and the extinguishing of fires, as well as emergency procedures when a fire occurs.

1. Causes of Fires in the Shop

a. Fire occurs only when three factors are combined. These are fuel, oxygen, and heat. The absence of any one of these factors will prevent a fire.

- 1) Fuel consists of any combustible material. Any common material in the shop from old rags to grease and oil can act as the combustible. All combustible materials must be properly stored to prevent the dangers of fire.
- 2) Heat is required to ignite the combustible. Heat can be provided from many sources in the shop including open flames, electric sparks, or high friction heat.
- 3) Oxygen must be present in order for fuels to burn. The absence of oxygen will prevent a fire or put one out. Storing combustibles in airtight conditions will prevent fires. Care must be taken when using airtight combustible containers to avoid the buildup of high pressure. A puncture to the container with all three factors present can cause a serious explosion.

2. Preventing Fires in the Shop

a. Familiarizing oneself with the factors involved in starting a fire can help lead to better prevention. The absence of any one of the factors described above will prevent a fire from starting, or put one out if it has already started. There are many safety precautions that can be taken in the shop to prevent the combination of fuel, heat, and oxygen.

- 1) Store fuels only in approved containers. These containers should be made of metal and ideally equipped with doors that seal automatically in the presence of fire.
- 2) Store fuels in a separate area from other flammable materials such as wood and paper.

130B-6

- 3) Keep the shop environment at a cool temperature with all areas being well below the combustion temperature of all materials. Most chemicals and liquid fuels will have data which label the combustion temperature and safe storage temperature range.
- 4) Use fires only in areas that are designated safe for that purpose. (Forge, cutting torch, etc.)

3. Extinguishing Fires in the Shop

- a. Fires are extinguished by removing any one of the three factors listed above. Different types of fires require different methods to extinguish them. Fires are categorized according to the type of fuel they burn. These classes of fires must be known in order to correctly extinguish all types of fires in the shop.
 - 1) Class A fires are termed as ordinary combustibles. These fires burn fuels such as wood, paper, and trash; they do not involve any liquid fuel or electricity. Such fires can easily be contained by smothering them, using water to cool them, or by removing the unburned fuel and letting the fire burn itself out.
 - 2) Class B fires are those that utilize flammable liquids for fuel. These fires are more difficult to extinguish and can be much more dangerous than class A fires.
 - 3) Class C fires involve electrical equipment. This type of fire not only has the risk of burning and smoke inhalation, but also of electrocution.
 - 4) Class D fires involve combustible metals. Very few metals will burn. Burning metals are very difficult to put out and require a Class D fire extinguisher in order to quench them.
- b. The fire classifications are based on how cheaply and easily the fires can be extinguished. Class A fires can be extinguished safely using water. Water is the cheapest and easiest fire retardant to apply. In some situations, such as in electrical fires, water is not safe to use due to the chance of electrocution.
- c. Fire extinguishers vary as do the types of fires. Each fire extinguisher is labeled with the types of fires it can put out. Symbols are used to indicate each type of fire extinguisher.

130B-7

- 1) The green triangle is used to designate fire extinguishers that can put out ordinary combustible fires.
- 2) A red square is designates Class B fires which involve flammable liquids.
- 3) Electrical equipment fires can be extinguished with a fire extinguisher labeled with a C surrounded by a blue circle.
- 4) Combustible metal fires are extinguished by a fire extinguisher that has a yellow star symbol with a D in the center.

d. Fire extinguishers have a variety of different ingredients, depending on their capabilities.

- 1) Extinguishers containing water that are powered by pump or gas pressure can be used on Class A fires only.
- 2) Carbon dioxide gas extinguishers are useful on both Class B and Class C fires.
- 3) Dry chemical extinguishers can be used on Class A, B, and C fires.
- 4) Fire extinguishers that emit foam are to be used on Class A and Class B fires only.
- 5) Class D fire extinguishers contain special chemicals that can extinguish combustible metal fires.

e. Fire extinguishers should not be used on humans and animals unless absolutely necessary. A blanket is used to smother fires on humans and animals.

f. Using a fire extinguisher involves three easy steps.

- 1) Locate the fire extinguisher and remove it from its holder. Hold the fire extinguisher upright and pull the ring pin.
- 2) Start back ten feet from the flames and aim the nozzle at the BASE of the fire.
- 3) Squeeze the lever and sweep the nozzle in a side-to-side motion across the base of the fire.

g. Shop students should have a lesson on the types of fires, the capabilities of the fire extinguishers in the shop, the location of the fire extinguishers, and the methods of using them.

h. Each fire extinguisher should be checked at least once a month to assure that it will be usable in case of an emergency.

F. Regardless of the safety precautions taken by the instructor, accidents continue to occur in the shop. Most of these accidents can be prevented if each student develops safe working habits. Many simple shop rules can lead toward the development of a sense of the importance of safe shop procedures.

1. Discourage horseplay in the shop. Shop work requires the undivided attention of the worker if a task is to be performed safely for everyone in the shop. 'Playing around' distracts from this safe attention.
2. Have students report any hazard to the instructor immediately. Many accidents occur because students believe that the instructor already knows about a hazard.
3. Have each student read the safety signs on equipment before using it and warning labels on all chemicals or materials to be used.
4. Have a safety orientation with the students regarding the placement of safety equipment, the school's safety procedures and each student's responsibility in the event of an accident.
5. Enforce all shop safety regulations at all times. Leniency often leads to ignorance of the rules when it comes to shop safety.

G. Safety Signs

1. Post safety signs on each piece of equipment and at the storage area for portable tools. (Signs are provided in this chapter)
2. Students will understand all safety procedures on the signs before using the equipment.
3. Students will follow all the safety rules posted on the signs while using the equipment.

H. Material Safety Data Sheets (MSD)

1. Idaho schools with the Resource Conservation and Recovery Act, the Idaho Hazardous Waste Management Act, and other federal and state laws, rules and regulations which pertain to inventory, use and disposal of hazardous materials and hazardous waists.
2. In complying with this law, Ag Departments are required to keep a MSD sheet on any hazardous material including; used oil, paint thinner, etc.
3. Check with your local school district, each district might have a different policy.

ACTIVITY:

1. Conduct a shop safety tour with the class.
2. Use slides, videos, and films to illustrate the importance of shop safety.
3. Conduct practice emergency drills to assess student performance in case of an accident.
4. Have students sign written contracts wherein they agree to abide by all the safety procedures; posted or un-posted rules, in the shop. (Page 130B-13)
5. Photo copy and post safety signs (Pages 130B-14 through 130B-38) on shop equipment.

References:

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Phipps, Lloyd J., and Miller, Glen M.(1998) AGRISCIENCE MECHANICS. Danville, IL: Interstate Publishing

Burke, Stanley R., and Wakeman, T. J. (1990) MODERN AGRICULTURAL MECHANICS, 2ed EDITION. Danville, IL: Interstate Publishing

Resources:

UTAH SAFETY COUNCIL
5263 SOUTH 300 WEST, SUITE 201
SALT LAKE CITY, UTAH 84107
1-800-933-5943

University of Idaho, Environmental & Health Safety
1-888-884-3246 ext. 6524

Special Materials and Equipment:

Fire extinguisher; layout of the shop, including safety exits; videos and films on safety practices in the shop.

Name _____

Date _____

1. What area of agriculture sees the greatest number of injuries and accidents?

2. What precautions can be taken to prevent accidents in the agricultural mechanics shop?

3. List and describe at least two building requirements that assure a safe agricultural mechanics shop.

4. Color coding is used in the shop to:
 - a. make tools easier to find
 - b. add color to an otherwise dull shop
 - c. alert people to dangers and hazards
 - d. all of the above

5. Which color is used to signify danger?
 - a. Red
 - b. Gray
 - c. Blue
 - d. Brown

6. Accidents among farmworkers most often involve:
 - a. burns
 - b. machinery
 - c. drowning
 - d. falls

7. Flammable liquids and dirty rags must be disposed of by:
 - a. throwing them in the trash
 - b. flushing them down the drain
 - c. burning them in a safe area outside of the shop
 - d. placing them in special metal containers that close in the presence of fire

8. Lumber and metal material should be stored:

- a. in a storage closet
- b. in vertical racks
- c. in any available corner of the shop
- d. in the overhead rafters

9. Tools are silhouetted in the tool cabinet in order to:

- a. make tools easier to locate
- b. easily identify missing tools
- c. allow the tool cabinet to be neatly organized every time the tools are returned
- d. all of the above

10. Which of the following can be used to extinguish a fire?

- a. Fuel
- b. Oxygen
- c. Water
- d. Heat

11. List and describe the four types of fires. What are the symbols and colors that designate each type?

12. Which of the following is classified as protective clothing?

- a. Coveralls
- b. Apron
- c. Lab coat
- d. All of the above

13. List the three steps involved in using a fire extinguisher.

14. What type of fire will a fire extinguisher containing water be useful on?

- a. Class A
- b. Class B
- c. Class C
- d. All of the above

ANSWER SHEET

1. The use of tools and machinery.
2. Development of safe work habits.
3. Any thing listed in Section B of this unit.
4. C
5. A
6. B
7. D
8. B
9. D
10. C
11. Class A – Green triangle
Class B – Red square
Class C – C surrounded by a blue circle
Class D – Yellow star with a D in the center
12. D
13. 1) Locate the fire extinguisher and remove it from its holder. Hold the fire extinguisher upright and pull the ring pin.
2) Start back ten feet from the flames and aim the nozzle at the BASE of the fire.
3) Squeeze the lever and sweep the nozzle in a side-to-side motion across the base of the fire.
14. Class A

SAFETY CONTRACT

1. I understand that eye protection needs to be worn correctly in the shop at all times without exception.
2. I will follow all safety procedures at all times without exception.
3. I understand that loose clothing, loose jewelry, including rings of any kind, long hair (not in a ponytail), and neckties (not protected by coveralls) can be dangerous in the shop and should not be worn.
4. I understand that Safety Signs are to be understood before using the equipment and the safety procedures are to be followed during its' use.
5. I understand that protective clothing is an important part of shop safety and that clean coveralls and leather boots should be worn at all times (especially in welding and agricultural fabrication).
6. I understand that horseplay is never allowed in the shop and can cause serious injury to myself and to other students around me.
7. I will report all accidents, no matter how minor.
8. I understand that cleaning the shop at the end of each class period is an important part of shop safety and I will participate at the end of every class or whenever it is needed.
9. I understand that running is never allowed in the shop at any time.
10. I understand that all tools and equipment, welding electrodes, steel, wood, and grease rags are to be stored properly.

Failure to comply with this safety contract can and will result in detentions, parent-teacher conferences, and/or expulsion from this class and any other shop class you are currently in and you will be kept out of any other shop classes in the future for safety and liability reasons.

Parent's Signature _____ Student's Signature _____

Instructor's Signature _____

Date _____

ACETYLENE WELDER

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Use proper shade lenses - shade 5 to 7
2. Assume that all metal is Hot in this area
3. Always chain cylinders to cart, bench, or walls
4. Keep oil and grease away from oxygen cylinders and equipment. Oil or grease burns violently in the presence of oxygen.
5. Test connection for leaks frequently with soap and water
6. Keep area clear of combustible materials
7. Stand on one side of gauges when opening cylinder valves
8. Never use a match to light the torch
9. Do not walk with a lighted torch or lay down a lighted torch. An unattended lighted torch may cause burns.
10. Never open acetylene valve more than 1 to 1 ½ turns and leave the shut-off wrench in position at all times in case the tank must be turned off quickly
11. Welding or cutting galvanized metal will produce poisonous fumes
12. Before welding a container that may have held a flammable material, it should be steam cleaned and filled with water

ARC WELDER

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Use proper shade lenses – shade 10 to 12
2. Wear protective clothing
3. Assume that all metal in the area is Hot until you have tested it
4. There is a possibility of being shocked if you are wet, standing on wet floors, or if the welder has loose connections
5. Make sure the welding area is free of combustible material
6. Make sure exhaust fan is running before starting to weld
7. Welding galvanized metal or surfaces painted with lead base paints produces poisonous fumes
8. Warn persons nearby before striking arc
10. Before welding containers which may have held combustible materials, steam clean them and fill with water
11. Wear eye protection while chipping
12. Do not throw electrode stubs on floor because of slipping hazard

STATIONARY BELT SANDER

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection
2. Use the lower half of the wheel
3. Do not use the machine if part of the belt is worn away. This will damage the rubber wheel.
4. Use pliers or vise grips for holding small stock
5. Do not use too much pressure. Pushing too hard on the wheel may cause you to lose your balance and fall toward the wheel.
6. Do not talk to anyone while operating this machine

PORTABLE CIRCULAR SAW

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection
2. Use only sharp blades
3. Always check location of power cord before starting the cut so cord is not in blade path
4. Make sure you have good footing and are well balanced
5. Use both hands on the saw
6. Clamp small pieces. Do not attempt to hold them with one hand and saw with the other.
7. Make sure guard is in proper place before laying the saw down after a cut
8. Make sure saw is unplugged before changing blades or making adjustments
9. Make sure blade guard is in good operating condition
10. Be sure ports are open to avoid overheating motor
11. Never try to support a piece of lumber with your leg or knee while sawing. Leg cuts are a common injury.

METAL CUT-OFF WHEEL

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection
2. Make sure stock is securely clamped in vise
3. Maintain enough pressure so as to cut rapidly, but not so much as to stop the machine
4. Keep hands away from wheel
5. Do not attempt to catch metal which is being cut off. The metal will be hot.
6. Do not attempt to cut more than one piece of metal at a time
7. Check disc of damage before each use

DRILL PRESS

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Wear eye protection
2. Use sharp drill bits only
3. Clamp your work - loose metal can cause serious injury
4. Remove chuck key before drilling
5. Place work on wood to prevent damage to table
6. Use proper speed: Slow speeds for large drills
 Fast speeds for small drills

Drilling speeds for steel in revolutions per minute

Drill Diameter	Carbon steel drill	High speed drill
1/4	458	917
1/2	229	458
3/4	153	306

7. Place long end of piece being drilled to your left so that if it happens to slip, it will not strike operator
8. Do not wear gloves, loose fitting clothing or jewelry
9. Never grab metal spirals - they may cause serious cuts
10. Do not allow anyone around you while drilling
11. If you have long hair, wear a hat or tie the hair back
12. Use slower feed when breaking through material

FLOOR SHEAR

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Never get hands close to cutting edges
2. Be cautious about sharp edges on metal after it is sheared
3. Do not leave the handle of the shear in the down position. This will cause tripping.
4. Do not cut more than one thickness of metal at a time.
5. Do not cut metal which is too heavy for the shear. This shear is designed to cut metal no more than _____ inches thick.
6. Do not cut hardened steel such as car spring
7. Shear blades should make close contact with each other through the duration of the cut

FORGE

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection
2. When lighting the forge, turn on the gas first, then the air
3. When turning off the forge, shut off the gas first, then the air
4. When the forge is not in use, use a gate valve ahead of the electric valve to shut off the gas
5. Assume that all metal is Hot in this area until you have tested it
6. Make sure tongs fit the work piece securely
7. Be sure hammer handles are in good shape and securely fastened to hammer heads
8. Do not strike the face of an anvil with a hammer. This can cause serious injury from flying chips of metal from the hammer.
9. When using a hot cutter or hardie, make sure everyone in the area knows you are cutting metal and the metal may fly.

BENCH GRINDER

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Wear eye protection
2. Tool rests should be as close as possible to grinding stones without touching them
3. After installing a new wheel, stand to one side and let the grinder run a full minute before using it
4. Do not grind on the side of the wheel. Side pressure may cause the wheel to break.
5. Keep fingers away from wheel. Use pliers for holding small pieces.
6. Keep stones dressed and trued. A shiny surface indicates a dull wheel. Vibration indicates out-of-roundness.
7. Do not use a stone that is worn down to $\frac{1}{2}$ of its original diameter

HYDRAULIC JACK

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Make sure the jack is capable of lifting the load
2. Check lift points carefully to avoid damage to the item being lifted and to the jack
3. When working under lifted objects, support the objects with jack stands and lower the jack.
Never work under anything which is supported only by the jack.
4. Never leave an object supported only by a jack

HYDRAULIC PRESS

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection
2. Make all adjustments before pressure is applied to work
3. Do not attempt to hand hold the work
4. Make sure everyone in the area knows you are using the press and that there is danger from flying metal
5. Stand behind the end of the press to avoid flying metal
6. Stop periodically to inspect the work to make sure everything is all right
7. Always remove pressure before leaving the area
8. Always use sufficient supports, clamps, or other devices to hold and support the work evenly

JOINTER

Do not operate this machine until you have received instructions in its proper use and understand all items on this sign.

1. Wear eye protection
2. Keep the guard over the blades and in good working order
3. Keep blades sharp
4. Always disconnect power when checking or removing blades
5. Limit the depth of cuts to 1/16"
6. Avoid jointing pieces shorter than 12 inches
7. Use a push stick for jointing pieces less than 2 inches wide
8. Get help before jointing the edge or face of long pieces
9. Do not use the jointer for stock containing knots, splits, paint, or nails
10. The jointer is designed for smoothing the edges of boards. It is not made for planing the flat sides or the ends of boards.
11. Be sure the fence is clamped in place
12. The stock should be run through with the grain, not against it

METAL LATHE

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection
2. Remove chuck key as soon as you finish loosening or tightening chuck. This habit will prevent the lathe from being turned on with the key still in the chuck.
3. Always revolve chuck by hand before turning on the power
4. Do not wear gloves, rings, or loose clothing
5. Always roll up sleeves
6. Keep cutting tool away from stock until machine is turned on
7. Always check automatic feed to determine its direction before starting a cut
8. Never reach over the rotating chuck
9. Do not touch revolving work or attempt to pull off cuttings
10. Do not attempt to change gears while lathe is running
11. Do not lean against machine

MIG WELDER

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear dry gloves and coveralls while operating this machine. More splatter or molten metal will be experienced than with ordinary arc welders.
2. Electrode should be touched to work very lightly before starting to weld. Excess pressure may cause electrode to coil inside of cable.
3. Do not touch electrode to bare skin. Since electrode is not coated, it may cause shock.
4. Be sure gas is turned on before starting to weld
5. Do not lay the torch on the welder
6. Periodically clean the torch nozzle. Excess pile up of splatter can stop the electrode feed and cause it to coil up inside the cable.
7. Keep the cable as straight as possible while welding to prevent binding the electrode
8. Keep eyes shielded after the weld is completed. Small pieces of slag explode from the weld as it cools.

PLANER

Do not operate this machine until you have received instruction on its proper use and understand all items on this sign.

1. Wear eye protection
2. Do not wear loose fitting clothing
3. Keep guards in place and in good working order
4. Check stock for loose knots and nails before planing
5. Use only sharp blades
6. Keep hands away from material nearing feed rolls
7. Never plane stock which is shorter than 2 feet, longer than the distance between the feed rolls or less than 1/4 inch thick
8. Never plane stock of different thicknesses; this can result in kickback
9. Do not overload the machine by taking too deep a cut
10. When shutting down, do not leave the machine until it has come to a complete stop

PORTABLE DRILLS

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection
2. Use only sharp drills
3. Avoid wearing loose clothing
4. Remove chuck key before drilling
5. Keep a firm grip on the drill. Be alert to the possibility of the bit catching and throwing you off balance.
6. Do not lock the switch in the “ON” position while the drill is being held with the hands
7. Use less pressure when breaking through the stock
8. Do not use bits larger than specified by the chuck size. This will cause overloading of the drill motor.
9. Be sure that stock being drilled is securely fastened before drilling
10. Use a center punch before starting to drill
11. Do not let drill bit spin in hole without cutting

PORTABLE DISC GRINDER

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Wear eye protection
2. See that other workers are out of range or are wearing eye protection
3. Do not lay the grinder down until it comes to a complete stop
4. Make sure you are balanced and have good footing
5. Hold the grinder firmly with both hands at all times
6. Check the location of the power cord at all times to avoid cutting it
7. Check for cracked or glazed grinding wheels frequently
8. Use the left-hand portion of the disc so the particles will fly away from you

RADIAL ARM SAW

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection
2. Use only sharp blades
3. Keep the table clean
4. Do not wear gloves, rings, or loose clothing
5. Always use anti-kickback fingers while ripping
6. Do not stand with your face directly in line with the blade
7. Check rotation of blade before ripping. The board should be pushed in against the rotation of the blade.
8. For cross cutting, the blade rotates down from the operator and the saw is pulled forward slowly. Cutting too fast may cause the saw to climb the board or stall.
9. Adjust blade so that it will be about 1/16" below the surface of the table

STEAM CLEANER

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Make sure water is flowing through the cleaner before lighting the burner
2. Check electrical connections so that they will not get wet and cause shocks while the steam cleaner is being used
3. Hold the hose by the insulated handgrip and wear gloves to prevent burns
4. Make sure everyone in the area is aware that hot water and steam are being used
5. Be sure the safety blow-out plug is pointed toward the floor
6. Be sure to keep a constant supply of water flowing into the steam cleaner
7. Do not operate the cleaner unless water droplets are emitted with the steam
8. When shutting down, turn off the burner and leave water flowing until it is cool, then turn off water. Do not leave until it is completely shut down.

TABLE-TYPE BAND SAW

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Make sure stock is securely clamped in vise
2. If saw teeth wear off unusually fast, reduce the speed
3. Keep moving parts lubricated
4. Keep hands away from blade while cut is being made
5. Keep adjustable blade guides as close as possible to the stock
6. Keep proper tension on blade
7. Place metal in saw in the proper position. When sawing angle iron, place both legs down, when sawing rectangular stock, place the widest side toward the saw blade.
8. When cutting short metal, place another piece of metal of equal width in the opposite end of the vise jaws. This will provide good grip on the metal being cut.
9. Gently lower the blade when starting the cut
10. Do not press down on the saw while it is cutting
11. Do not leave saw unattended while it is running

TABLE SAW

Do not operate this machine until you have received instructions on its proper use and you understand all items on this sign.

1. Wear eye protection
2. Use only sharp blades
3. Keep table clean
4. Do not wear gloves, rings, or loose clothing
5. Always use the guard for cross cutting and ripping
6. Use the rip fence for ripping and the miter gauge for cross cutting. Never attempt to use the rip fence and the miter gauge at the same time.
7. The blade should be adjusted so that it protrudes no more than 1/4" above work
8. Never allow your fingers too close to the saw blade. Use a push stick.
9. Do not attempt to clear the table of scraps while the saw is running
10. Do not stand with your face directly in line with the saw blade
11. Make sure saw is disconnected from the power source while changing blades and making adjustments

TIG WELDER

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear dry gloves and coveralls while operating this machine
2. Touching the electrode to bare skin may cause shock
3. Be sure gas is turned on before starting to weld
4. On water cooled torches, keep a constant watch for leaks in the line. Wet cables or floors lead to shocks.
5. A 2% solution of silver nitrate will turn magnesium black and will not affect aluminum. Magnesium will burn if overheated. If a magnesium fire is experienced, discontinue the arc, but keep the inert gas directed on the flame until the fire is extinguished.
6. Do not turn off welder until the time delay switch has shut off the flow of gas
7. Do not lay the torch on the welder
8. Touching the electrode on the work piece, using too small a nozzle or insufficient gas pressure, or using too long an arc will cause black welds
9. Clean metal with a grinder or wire brush that is used for aluminum only

UPRIGHT BAND SAW

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Use only sharp blades
2. Do not wear gloves, rings, or loose clothing
3. Keep both hands on the same side of the blade while pushing work through the saw. This will prevent binding.
4. Do not allow fingers any closer than 2 inches from the blade. Keep hands to one side of the blade. Use a push stick.
5. Do not reach around and attempt to pull stock through the saw
6. Saw guide should be no more than 1/2" above stock being cut
7. Use vise grips to hold round stock. Round stock tends to twist and may break the blade or cause it to fly off.

POWER WIRE BRUSH

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear eye protection - wires from the wheel could lodge in your eye
2. Do not wear gloves, rings or loose-fitting clothing
3. Hold work at or below the center of the wheel. Any object caught by the wheel will then be thrown down.
4. Use pliers to hold small objects to be brushed
5. Do not use excessive pressure

WOOD LATHE

Do not operate this machine until you have received instructions on its proper use and understand all items on this sign.

1. Wear proper eye protection
2. Do not wear gloves, rings, or loose clothing
3. Always roll up sleeves
4. Make sure tail stock is securely locked in place
5. Allow all glued work to set properly before turning
6. Rotate the work by hand before turning on power
7. Hold lathe tools securely with both hands
8. Keep lathe tools sharp
9. Always stop machine before measuring stock
10. Keep the tool rest as close as possible to the work
11. Turn large diameter objects at slow speeds
12. Remove tool rest when sanding or finishing

130C-1

MEASURING

AG 130-C

UNIT OBJECTIVE

After completion of this unit, students will be able to identify the standard measurements using a tape measure, ruler, yardstick, and micrometer. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Understand basic terms used in measuring.
2. Identify different types of measuring tools.
3. Measure objects correctly with a ruler, tape, or framing square.
4. Measure to within $\frac{1}{16}$ of an inch with a ruler.
5. Calculate area and volume when given dimensions using Standard measurements.
6. Read and measure with a micrometer within $\frac{1}{1000}$.

130C-2

MEASURING

A. Measuring is essential to the design and construction of landscapes, facilities, buildings and equipment. Measuring is used to:

1. Create drawings, plans or models of projects to be built.
2. Measure and cut materials to size.
3. Place materials properly in construction.
4. Select proper size replacement parts for tools and equipment.
5. Determine quantity of materials needed for projects.
6. Calculate area and volume.

B. Common measuring tools and their uses:

1. Ruler or Yardstick - rigid measuring devices. Specialized rules or scales are made for drawing or drafting.
2. Tape Measure - flexible measuring device typically used in construction and landscaping. Large tape measures are available for measuring large areas such as field plots.
3. Framing Square - L shaped measuring device used in construction. Useful for drawing right angles on materials to be cut.
4. Calipers - pincher like measuring devices used to measure the diameter of objects.
5. Micrometers - exceptionally accurate calipers for making very small measurements. Often used in machinery repair and in the construction of precision tools.
6. Surveyors rod - used with a sight level or transit to measure vertical height. Important for leveling building sites, preparing forms for concrete, grading roads and ditches, laying pipe.

C. Units of measurement:

1. English Fractional Rule - Inches are divided into 8, 16, 32 or 64 equal segments.
2. English Decimal rule - Inches are divided into 10 or 100 equal segments.
3. Metric Rule - Basic unit of length is the meter. Each meter is divided into 100 centimeters. Each centimeter is divided into 10 millimeters.
4. See Tables 1-3 for a comprehensive listing of units of linear, square and cubic measurements for the English (Table 1) and Metric (Table 2) systems. Table 3 lists equivalencies of Metric and English units useful for converting measurements between systems.

D. Understanding Metric Measurements

1. The metric system has the advantage of being a completely decimal system.
2. The units of measure in the metric system relate to one another by multiples of ten. This makes the metric system mathematically logical and easy to use.
3. Instead of working with complicated division and multiplication to change from one measurement unit to another, the decimal point is merely moved.
 - a. To change sizes of metric units, multiply or divide by 10, 100, 1,000 or 1,000,000, which is as simple as moving a decimal point.
 - b. For example, to change 357 centimeters to meters, divide by 100. The answer is obvious without figuring--3.57 meters. Metric measures make calibration of instruments and equipment much easier.
4. Below is a table of metric prefixes whose meaning indicates whether to multiply or divide when changing measurement:
 - a. Mega- = 1,000,000 times the basic unit (meter, liter, grams).
 - b. Kilo- = 1,000 times the basic unit.
 - c. Hecto- = 100 times the basic unit.
 - d. Deca- = 10 times the basic unit.
 - e. Deci- = $1/10$ times the basic unit.
 - f. Centi- = $1/100$ times the basic unit.
 - g. Milli- = $1/1000$ times the basic unit.
 - h. Micro- = $1/1,000,000$ times the basic unit.

ACTIVITY:

1. Add and subtract both English and metric units of measure; then discuss the use of common fractions in English unit manipulation and the use of decimals in metric unit manipulation.
2. Perform English-to-metric and metric-to-English conversions.
3. Compare U.S. standard measure and metric measure tools and identify engines and machinery which require metric measure tools.

Table 1. English Units of Measure

Linear Units (Length)

12 inches (in. or ")	=	1 foot (ft or ')
3 feet	=	1 yard (yd)
16 1/2 feet	=	1 rod (rd)
5 1/2 yards	=	1 rod
320 rods	=	1 mile (mi)
5,280 feet	=	1 mile
1,760 yards	=	1 mile
1 furlong (fur)	=	1/8 mile or 660 feet

Square Units (Area)

144 square inches (sq. in. or in. ²)	=	1 square foot (sq. ft or ft ²)
9 square feet	=	1 square yard (sq. yd or yd ²)
30 1/4 square yards	=	1 square rod (sq. rd or rd ²)
160 square rods	=	1 acre (A)
43,560 square feet	=	1 acre
640 acre	=	1 square mile (sq. mi or mi ²)

Cubic Units (Volume)

1,728 cubic inches (cu in. or in. ³)	=	1 cubic foot (cu ft or ft ³)
27 cubic feet	=	1 cubic yard (cu yd or yd ³)
128 cubic feet	=	1 cord (cd) - measure of fire wood

Table 2. Metric Units of Measure

Linear Units (Length)

1 kilometer (km)	=	1,000 meters
1 hectometer (hm)	=	100 meters
1 decameter (dkm)	=	10 meters

Square Units (Area)

1 square centimeter (cm^2)	=	100 square millimeters (mm^2)
1 square decimeter (dm^2)	=	100 square centimeters (cm^2)
1 square meter (m^2)	=	10,000 square centimeters (cm^2)
10,000 square meters	=	1 hectare

Cubic Units (Volume)

1 cubic centimeter (cm^3)	=	1,000 cubic millimeters (mm^3)
1 cubic meter (m^3)	=	1,000,000 cubic centimeters (cm^3)
1,000 cubic centimeters	=	1 cubic decimeter (dm^3)
1,000 cubic centimeters	=	1 liter (l)
1 cubic centimeter (cc)	=	1 milliliter (ml)

130C-6

Table 3. English to Metric Conversions

Linear Units (Length)

1 in	=	25.4 mm	or	1 mm	=	0.03937 in
1 in	=	2.54 cm	or	1 cm	=	0.3937 in
1 ft	=	30.48 cm	or	1 m	=	39.37 in
1 ft	=	0.3048 m	or	1 m	=	3.281 ft
1 yd	=	0.9144 m	or	1 m	=	1.0936 yd
1 mi	=	1.6093 km	or	1 km	=	0.6214 mi

Square Units (Area)

1 in ²	=	6.452 cm ²	or	1 cm ²	=	0.1549 in ²
1 ft ²	=	0.0929 m ²	or	1 m ²	=	10.76 ft ²
1 yd ²	=	0.8361 m ²	or	1 m ²	=	1.196 yd ²
1 mi ²	=	259 ha				
1 mi ²	=	2.589 km ²				
1 acre	=	0.4047 ha		1 ha	=	2.471 acres

Cubic Units (Volume)

1 in ³	=	16.387 cm ³	or	1 cm ³	=	0.06102 in ³
1 ft ³	=	0.0283 m ³	or	1 m ³	=	35.32 ft ³
1 yd ³	=	0.7646 m ³	or	1 m ³	=	1.208 yd ³

To convert units, multiply unit on left by conversion factor on right.
 (e.g. 10 in x 25.4 mm/in = 254 mm)

CALCULATING AREA AND VOLUME

A. Calculating Area

1. Square measure is a system for measuring area. The area of an object is the amount of surface contained within defined limits. For example, use a square that covers four square inches.

- a. The perimeter of the square is the total length of its sides.

$$\begin{aligned}\text{perimeter} = P &= 2 \times \text{length} + 2 \times \text{width} \\ &= (2 \times 2) + (2 \times 2) = 8 \text{ in}\end{aligned}$$

- b. The area of a square or rectangle is equal to the length times the width.

$$\begin{aligned}A (\text{area}) &= \text{length} \times \text{width} \\ &= 2 \times 2 = 4 \text{ in}^2\end{aligned}$$

2. Finding the area of circles.

- a. The perimeter of a circle is equal to the diameter (D) of the circle times pi (π). π is the ratio of a circle's perimeter to its diameter. This ratio is $22/7$ or approximately 3.14. Pi is constant for all circles. The perimeter of a circle is known as its circumference.

$$\text{Perimeter of a circle} = \pi \times D = 3.14 \times D$$

- b. The area of a circle is equal to pi times the radius squared. The radius of a circle is half the diameter:

$$\text{Area of a circle} = \pi \times R^2$$

- c. For example, a circular grain silo has round floor 18 feet in diameter.

$$\begin{aligned}\text{The perimeter (circumference) of the floor is} \\ \text{Perimeter} &= 3.14 \times 18 = 56.52 \text{ feet}\end{aligned}$$

$$\begin{aligned}\text{The area of the floor is} \\ \text{Area} &= 3.14 \times (9 \times 9) = 3.14 \times 81 = 254.34 \text{ ft}^2\end{aligned}$$

130C-8

3. Finding the area of the curved surface of a cylinder.

- a. The curved-surface area of a cylinder is equal to the circumference ($\pi \times D$) of an end times the height (H).

$$\text{Area of a cylinder} = A = (\pi \times D) \times H$$

- b. Example - If the silo in the example above is 50 feet tall:

The area of the sides of the silo is:

$$\text{Area} = (3.14 \times 18) \times 50 = 2826 \text{ ft}^2$$

4. Finding the area of a triangle.

- a. The area of a triangle is equal to one half the base (B) times the height (H).

$$\text{Area} = 1/2 \times (\text{base} \times \text{height})$$

- b. Example - what is the area of the triangular wall of a storage shed with a base of 2 meters and a height of 3 meters

The area of the wall is:

$$\text{Area} = 1/2 \times (2 \times 3) = 3 \text{ m}^2$$

ACTIVITY:

1. Take actual measurement of plots and fields around the school shop or farm and determine individual and total acreage.
2. Determine how much sheet metal was used in constructing a barrel, feed bin, etc. Calculate the amount of paint required to paint the inside and outside of the silo in the example above.

B. Calculating Volume

1. A cubic measure is a system of measurement of volume or capacity of an object expressed in cubic units. A cubic measure requires three dimensions:
 - a. Linear measure adds only one dimension to find total distance.
 - b. Square measure multiplies two dimensions to find area of a surface.
 - c. Cubic measure multiplies three dimensions (length, width, and height) to find the volume of various types of structures and containers.

- d. When determining the volume of an object, all measurements must be expressed in the same units of measurement.

2. Finding the volume of rectangular solids and cubes.

- a. The volume of a rectangular solid is equal to the length (L) times the width (W) times the height (H).

$$\text{Volume of a rectangular solid} = L \times W \times H$$

- b. Example - Determine the volume of the rectangular crate

$$\text{Volume} = 6' \times 4' \times 4' = 96 \text{ ft}^3$$

- c. A cube is a special rectangular solid where length = width = height.
 d. The volume of a triangular prism is equal to the area of the triangle times the length of the prism.

3. Finding the volume of cylinders and cones.

- a. The volume of a cylinder is equal the area of the circular base ($\pi \times R^2$) times the height (H) of the cylinder.

$$\text{Volume of a cylinder} = (\pi \times R^2) \times H$$

- b. The volume of a cone is equal to 1/3 times the area of the circular base ($\pi \times R^2$) times the height (H) of the cone.

$$\text{Volume of a cone} = 1/3 \times (\pi \times R^2) \times H$$

ACTIVITY:

1. Measure various rectangular and cylindrical containers or buildings and determine their volumes.
2. Measure a paper-cone cup and calculate how much water it can hold.

RULES, YARDSTICKS, AND TAPE MEASURES

A. Ruler

1. Rules come in a variety of body lengths, most commonly 6 - 12 inches, sometimes 13 inches if metric measurements are on the other side.
 - a. An inch is a unit of measurement used in the United States
 - b. Usually divided into 8, 16, or 32 segments (Page 130C-14)
2. 12 inches equals 1 foot.
3. 3 feet equals 1 yard
4. Rules are mostly used for measuring and drawing straight lines in drafting and sketching.

B. Yardsticks

1. Yardsticks have a body length of 36 inches equaling 3 feet, sometimes 3 feet and 3 inches if metric measurements are on the other side equaling one meter
2. Yardsticks are mostly used in measuring the length of cloth products and the water level in open top water tanks.

C. Tape Measures

1. Tape measures are flexible measuring devices and come in a large variety of lengths
 - a. 10 ft, 16 ft, 20 ft, 25 ft, 30 ft, 50 ft, 100 ft, etc.
2. Tape measures are mainly used in construction, framing, fabrication, landscape layouts, surveying, etc.
3. Marks on the tape measure
 - a. Foot marks, every 12 inches along a tape measure there will be a marker to indicate the distance in feet. There will be a mark at 12 inches, 24 inches, 36 inches, etc.
 - b. Spacing Studs, studs used in framing walls are on 16-inch centers. At 16-inch intervals on a tape measure there will be a mark to indicate the spacing of studs. There will be a mark at 16 inches, 32 inches, 48 inches, etc.
 - c. Truss marks, every $19\frac{3}{16}$ inches along a tape measure there will be a small black diamond. This indicates the center for trusses.

CALIPERS AND MICROMETERS

A. Calipers

1. Definitions

- a. Calipers are instruments used to measure the diameter or thickness of an object
- b. Both inside and outside calipers are used
 - 1) Inside calipers measure inside distances such as the diameter of an engine cylinder
 - 2) Outside calipers measure the outside of round objects such as crankshafts

2. Reading Calipers

- a. Many economical calipers are not direct-reading measuring tools but require a separate rule or scale to measure their settings
 - 1) Such calipers are used as measurement transfer tools similar to small-hole and telescoping gauges
 - 2) They transfer the internal measurement of an engine part to a micrometer caliper for precision reading
- b. More expensive calipers have their own dimension scales
- c. A slide caliper (vernier caliper) is a direct-reading measuring instrument used to make fast, accurate measurements

B. Micrometers

1. Definitions and Parts Identification (Page 130C-22)

- a. The micrometer is a direct-reading, precision measuring tool, which can measure to 0.001 inch (one thousandths of an inch)
 - 1) Micrometers come in various sizes for different size objects
 - 2) They are very delicate and are ruined if dropped
- b. To use a micrometer properly, the mechanic should be able to identify its' parts

2. Using and Reading a Micrometer

a. Zeroing out the micrometer

- 1) Screw the adjusting nut in until the zeros on the sleeve and thimble line up. Note the tightness of the adjusting nut, the same tightness will be used when taking measurements.
- 2) Micrometers 2 inch or larger will need a standard to be zeroed out

b. To measure with a micrometer, place the object to be measured between the anvil and the spindle

- 1) Screw the spindle until it touches the object
 - a) Adjust the micrometer to the same tightness as when the micrometer is zeroed out
 - b) Over tightening will ruin the micrometer and take inaccurate measurements

3. Reading the micrometer

- a) Identify the frame size of the micrometer being used and write down the smallest number of inches that can be read
 - 1) If the micrometer has a 1-to-2 inch frame, write down 1.000 in.
 - 2) One inch is already given since the anvil and the spindle can be no closer together than one inch
- b) Every revolution of the thimble is equal to 0.025 in. (twenty-five thousandths of an inch)
- c) List the number of tenths of an inch (hundred thousandths) indicated by the largest number visible between the sleeve
- d) Count the number of lines easily visible between the last tenths marking and the thimble then multiply the number by 0.025
- e) Locate the line of the thimble that matches the horizontal line on the sleeve and write its' number down in thousandths of an inch
- f) Total the values

References:

Cooper, E. L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Hokanson, C. M. (1984). APPLIED PROBLEMS IN MATHEMATICS FOR AGRICULTURE. Danville, IL:

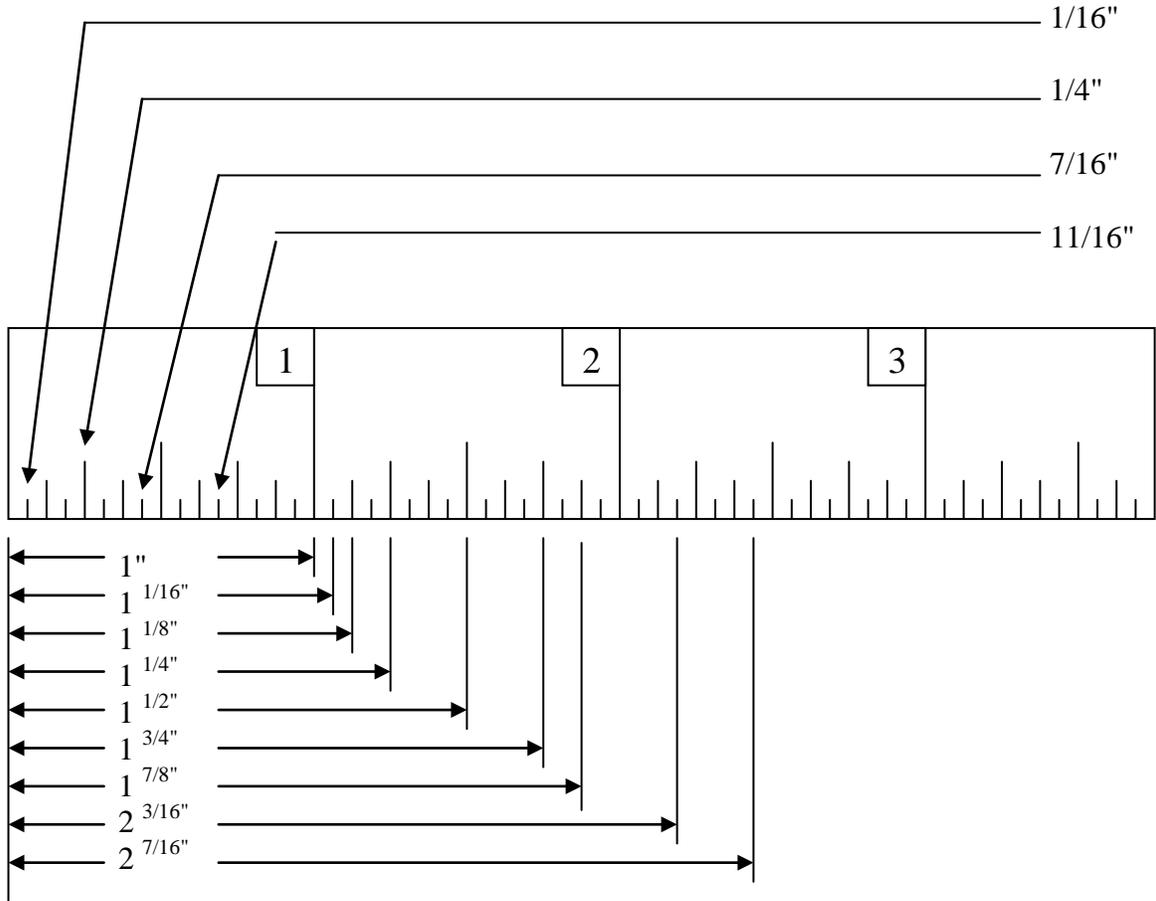
THE STARRETT BOOK FOR STUDENT MACHINISTS,(1998) The L. S. Starrett Company, Athol, Massachusetts 01331

Special Material and Equipment:

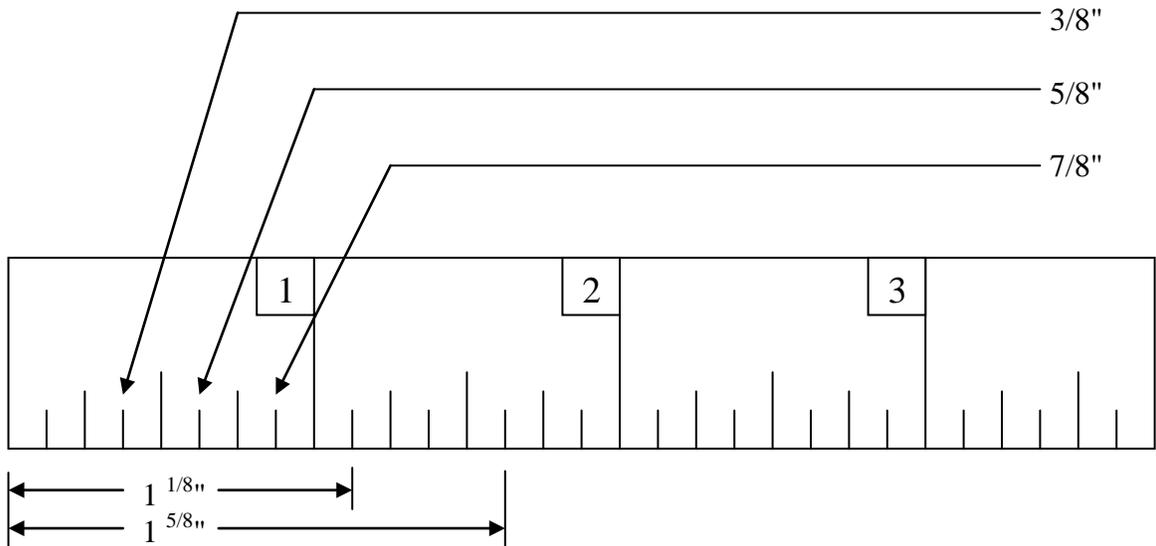
Ruler or Yardstick, Tape Measure, Framing Square, Calipers, Micrometer, Calculators (optional), 25' measuring tape, objects and land to measure

MEASURING WITH A RULER

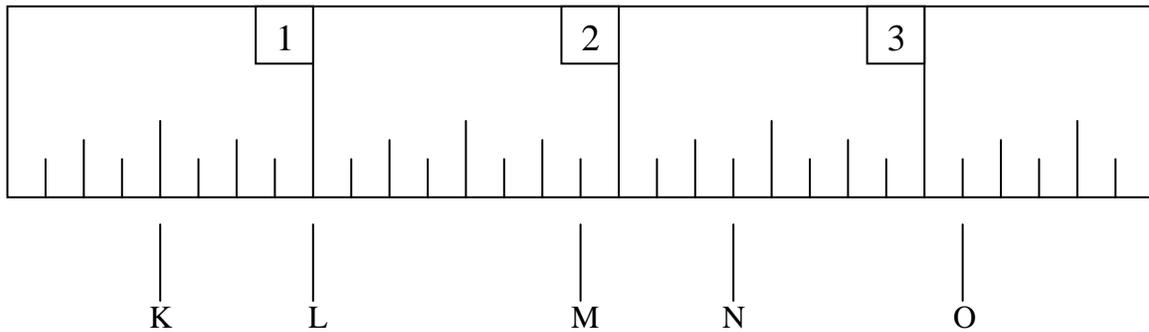
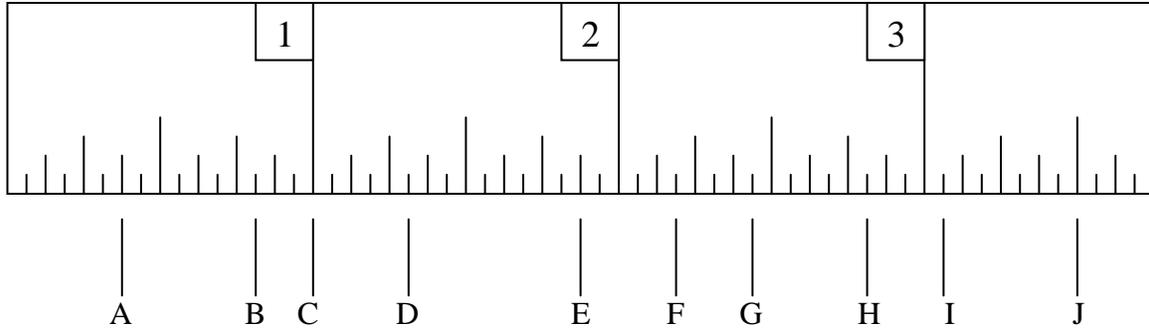
1/16th INCH SCALE



1/8th INCH SCALE



MEASURING WITH A RULER, WORKSHEET



Write down the measurements for the location at each letter.

- 1. A=_____
- 2. B=_____
- 3. C=_____
- 4. D=_____
- 5. E=_____

- 6. F=_____
- 7. G=_____
- 8. H=_____
- 9. I=_____
- 10. J=_____

- 11. K=_____
- 12. L=_____
- 13. M=_____
- 14. N=_____
- 15. O=_____

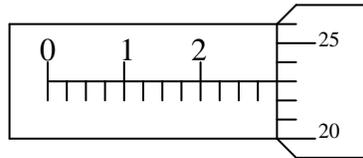
Measure lines 16 through 20 to the nearest $1/16^{\text{th}}$ and record the results.

- 16. _____ 16=_____
- 17. _____ 17=_____
- 18. _____ 18=_____
- 19. _____ 19=_____
- 20. _____ 20=_____

READING THE MICROMETER

Picture shows only the sleeve and part of the thimble
Measure to the nearest one thousandth.

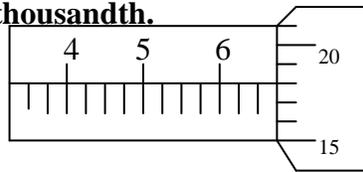
Example A
0 – 1 inch micrometer



Sleeve Reading: 0.200 inch
 0.025 inch
 0.025 inch
 0.025 inch
 Thimble Reading: 0.023 inch
 Total Reading: 0.497 inch

Measure to the nearest one thousandth.

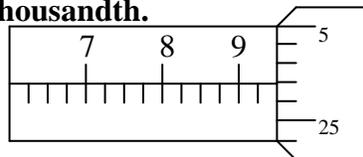
Example B
1 – 2 inch micrometer



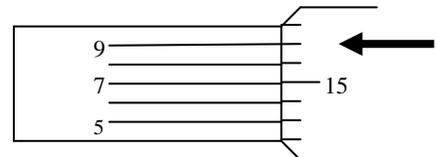
1 – 2 inch micrometer = 1.000 inch
 Sleeve Reading: 0.600 inch
 0.025 inch
 0.025 inch
 Thimble Reading: 0.018 inch
 Total Reading: 1.668 inches

Measure to the nearest ten thousandth.

Example C
2 – 3 inch micrometer



Top View, Vernier Scale



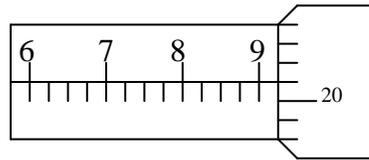
2 – 3 inch micrometer: 2.0000 inch
 Sleeve Reading: 0.9000 inch
 0.0250 inch
 0.0250 inch
 Thimble Reading: 0.0010 inch
 Vernier scale: 0.0009 inch
 Total Reading: 2.9519 inches

MICROMETER WORKSHEET

Fill in the correct measurement in the blank.

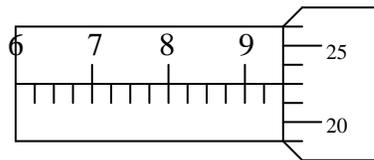
Measure to the nearest one thousandth.

0 – 1 inch



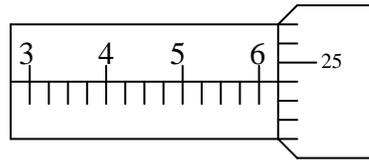
1. _____

0 – 1 inch



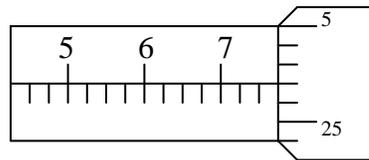
2. _____

1 – 2 inch



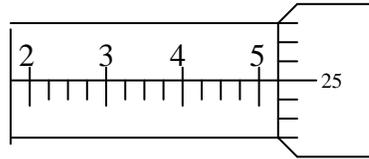
3. _____

1 – 2 inch



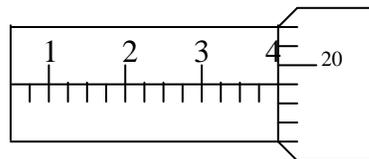
4. _____

0 – 1 inch



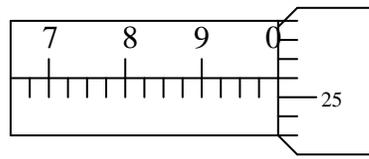
5. _____

2 – 3 inch



6. _____

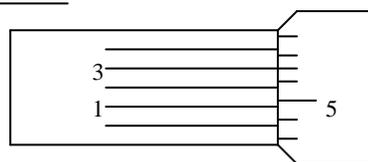
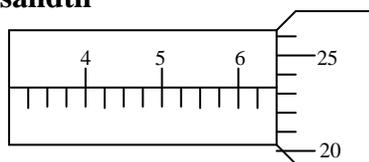
0 – 1 inch



7. _____

Ten Thousandth

2 – 3 inch



8. _____

WORKSHEET, VOLUMES AND AREAS

Calculate the area of squares, rectangles and triangles.

1. Calculate the perimeter and area of a 6" x 6" square.

$$P = 2 \times \text{length} + 2 \times \text{width}$$

$$A = \text{length} \times \text{width}$$

2. Calculate the perimeter and area of a 3" x 8" rectangle.
(use the formulas in the question above)

3. Calculate the area of a triangle, with a 4' base and 5' high.

$$A = \frac{1}{2} \times (\text{base} \times \text{height})$$

Calculate the area of a circle and cylinder.

4. Calculate the perimeter and area of a 12" diameter circle.

$$\text{Perimeter} = \pi \times D$$

$$\text{Area} = \pi \times R^2$$

5. Calculate the perimeter and area of a 3" circle.

$$\text{Perimeter} = \pi \times D$$

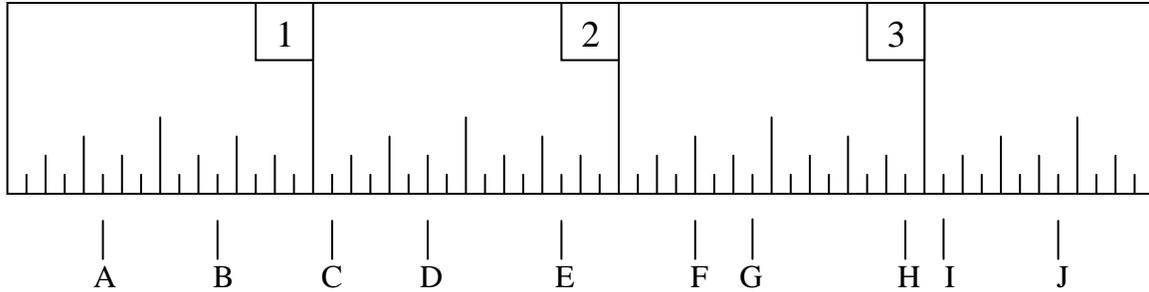
$$\text{Area} = \pi \times R^2$$

6. Calculate the area of a 4" diameter 7" deep cylinder

$$\text{Area of a circle} = \pi \times R^2$$

$$\text{Area of a cylinder} = \pi \times R^2 \times \text{height}$$

MEASURING EXAM, RULES AND MICROMETERS

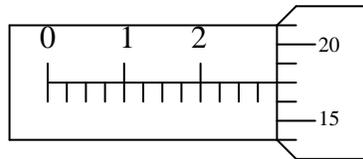


Write down the measurements for the location at each letter

- | | | |
|------------|------------|-------------|
| 1. A=_____ | 5. E=_____ | 9. I=_____ |
| 2. B=_____ | 6. F=_____ | 10. J=_____ |
| 3. C=_____ | 7. G=_____ | |
| 4. D=_____ | 8. H=_____ | |

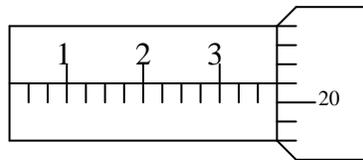
Write down the measurement to the nearest one thousandth.

11. 0 –1 inch



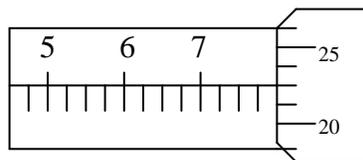
11. _____

12. 2 –3 inch



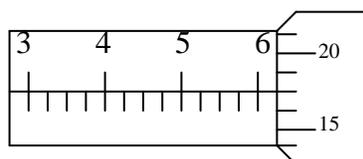
12. _____

13. 1 –2 inch



13. _____

14. 1 –2 inch

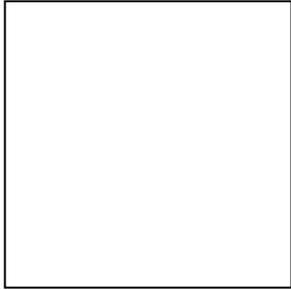


14. _____

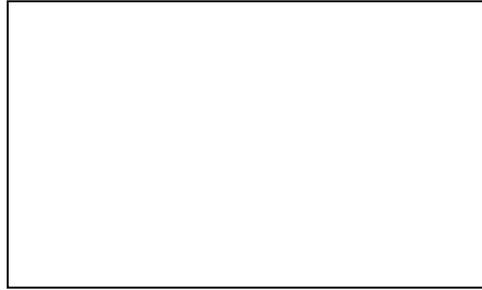
VOLUME AND AREA

Using your ruler, measure the distance around these boxes and calculate the perimeter and area. $P = 2 \times \text{length} + 2 \times \text{width}$ $A = \text{length} \times \text{width}$

15.



16.



Perimeter = _____

Perimeter = _____

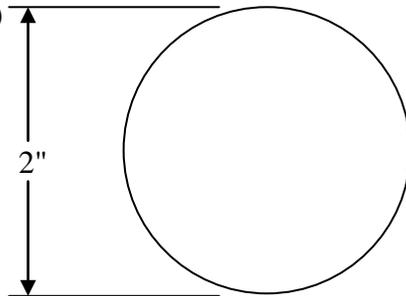
Area in Square inches = _____

Area in Square inches = _____

Calculate the area of a circle. (circle is not to scale)

17. Area in square inches. = _____

Formula: $\pi \times R^2$



18. Calculate the area of a cylinder, 2 ½" diameter and 3" high.

Formula: $\pi \times R^2 \times \text{height}$

ANSWER SHEET

Worksheet, Ruler

1. $3/8$ "
2. $13/16$ "
3. 1"
4. 1, $5/16$ "
5. 1, $7/8$ "
6. 2, $3/16$ "
7. 2, $7/16$ "
8. 2, $13/16$ "
9. 3, $1/16$ "
10. 3, $1/2$ "
11. $1/2$ "
12. 1"
13. 1, $7/8$ "
14. 2, $3/8$ "
15. 3, $1/8$ "
16. 4, $1/8$ "
17. 1, $15/16$ "
18. 2, $5/8$ "
19. 1"
20. 3, $5/8$ "

Worksheet, Micrometer

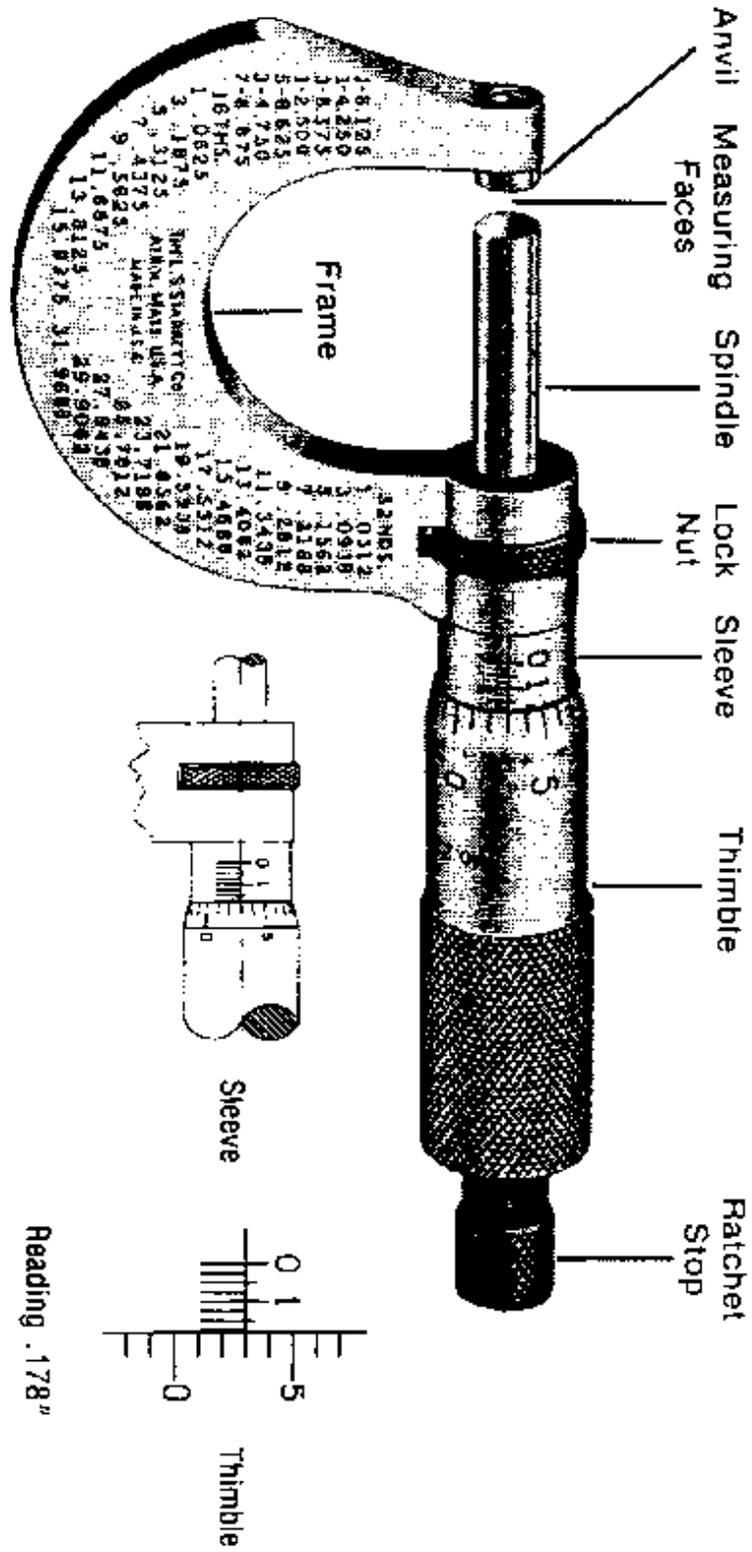
1. 0.921
2. 0.948
3. 1.624
4. 1.777
5. 0.525
6. 2.394
7. 1.001
8. 2.6483

Worksheet, Volume

1. 24" and 36in^2
2. 22" and 24in^2
3. 10ft^2
4. 37.7" and 113in^2
5. 9.42" and 28.3in^3
6. 351in^3

Measuring Exam

- | | |
|-----------------|--------------------------------|
| 1. $5/16$ " | 10. 3, $7/16$ " |
| 2. $11/16$ " | 11. 0.287 |
| 3. 1, $1/16$ " | 12. 2.371 |
| 4. 1, $3/8$ " | 13. 1.797 |
| 5. 1, $13/16$ " | 14. 1.617 |
| 6. 2, $1/4$ " | 15. 6" and $2\ 1/2\text{in}^2$ |
| 7. 2, $7/16$ " | 16. 8" and $3\ 3/4\text{in}^2$ |
| 8. 2, $15/16$ " | 17. 3.14in^2 |
| 9. 3, $1/16$ " | 18. 14.71in^2 |



130D-1

DRAFTING AND SKETCHING

AG 130-D

UNIT OBJECTIVE

After completion of this unit, students will understand basic drawing and sketching skills and be able to use the proper tools for drawing and sketching. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Identify the different types of lines used in a drawing or layout.
2. Identify the three types of drawings (orthographic, isometric, and oblique).
3. Use a ruler or architect's scale in drafting.
4. Interpret a working drawing.
5. Interpret three-view (orthographic) drawings.
6. Sketch an object, using paper and pencil.
7. Plan and lay out a construction project.
8. Calculate construction costs for a given project.
9. Assemble and finish a project.

PREPARING A WORKING DRAWING

A. Sketches and Working Drawings

1. Sketches are freehand drawings of an object for a project done in order to get the idea down on paper.
 - a. Sketches are not usually drawn to scale.
 - b. Neatly drawn sketches with fairly accurate dimensions are usually sufficient for simple projects.
 - c. Sketches of larger and more complicated projects can serve as the basis for accurate working drawings.
2. Working drawings are complete drawings done in universal graphic language so that the object depicted can be constructed from the drawing alone without additional information.
 - a. Dimensions - Working drawings use lines scaled to the dimensions of the actual objects.
 - b. Views - Working drawings show specific views of an object with enough detail to enable project construction.
 - 1) Most working drawings show three separate sides of an object from three flat, head-on views.
 - 2) Pictorial drawings show three sides of an object together in one view.

B. Types of Working Drawings

1. Orthographic Drawings

- a. They show a flat, head-on view of every side that differs in size and shape.
- b. They may illustrate six views of the object: top, bottom, front, back, right side, and left side (the ends).
- c. They usually use only three views: top, front, and end.

2. Pictorial Drawings

a. Isometric Drawings

- 1) Isometric drawings are based on three lines or axes: one vertical axis with two others at 60 degrees to the vertical.

130D-3

- 2) Such drawings can show the true dimensions of an object's top, side, and end views.
- 3) The line angles of isometric drawings are not accurate, but are nevertheless used to give the object a three dimensional effect.

b. Oblique Drawings

- 1) Oblique drawings are based on three lines or axes similar to isometric drawings, except that one axis is horizontal, one vertical, and the third is at a convenient angle (typically 30 degrees to 45 degrees) to the horizontal.
- 2) Like isometric drawings, oblique drawings can depict the true dimensions of an object's top, side, and end.
- 3) The front of an oblique drawing always shows the true shape of that side of the object from a head-on view.
- 4) If the object being drawn has a side with curved or irregular lines, this side is used for the front.

SAFETY IN SKETCHING, DRAWING, AND PLAN READING

Some pieces of drawing equipment have sharp points; therefore, when using these drawing instruments, you should exercise care to prevent injury to yourself and/or others.

Safety Practices:

1. Keep sharp-pointed drawing instruments stored in their case to prevent injury to yourself and/or others.
2. When using drawing instruments, lay them in a safe place to prevent them from falling.
3. To prevent drawing instruments from falling, fasten the drawing tabletop securely before you start to draw.
4. Never play with sharp-pointed drawing instruments.

C. Constructing Working Drawings

1. Drawing to Scale

- a. Scale drawing permits the size of the object to be reduced proportionally in order for it to be drawn on the size of paper chosen.
- b. Common scales of a drawing may be 1/8," 1/4," 3/4," 1," and 3," to represent one foot. For example, 1/8 inch = 1 foot.

130D-4

c. An architect's scale is the most common type of scale used for drawing agricultural projects.

- 1) Its main divisions at the end of the scale, which are in inches or fractions of an inch, represent one foot.
- 2) The divisions are subdivided even smaller to represent inches and fractions of an inch.
- 3) An architect's triangular scale has six faces with a different scale on each end of each face.

d. Use of engineer's paper (graph paper) permits drawing to scale without an architect's scale. It is cross-ruled paper with 4, 8, or 12 divisions to the inch. Simply count the number of divisions in order to draw a line to scale.

2. Sheet Layout (Example, Figure 1 on page 130D-10)

a. Attach a sheet of paper to the drawing board with tape.

- 1) If a T square and triangles will be used as drawing aids, use the T square to align the paper with the left edge of the drawing board.
- 2) If a T square is not available, tracing paper or vellum may be attached with engineer's paper under it to serve as a drawing aid.

b. Draw border lines $1/2$ inch from the paper's edge, $3/4$ inch from the bottom.

c. Make a title block at the bottom of the paper which includes the following information about the drawing:

- 1) The name of the person doing the drawing.
- 2) The date of the drawing.
- 3) The title of the drawing.
- 4) The scale of the drawing.

3. Types of Lines Used in Drawings (Page 130D-9)

a. Border line: a heavy, solid line drawn parallel to the edge of the drawing paper.

b. Object line: a solid line representing the visible edges and form of an object.

c. Hidden line: a series of dashes which indicate the presence of hidden edges.

130D-5

- d. Extension line: a solid line indicating the exact area specified by a dimension.
- e. Dimension line: a solid line with arrowheads at both ends to indicate the length, width, or height of an object.
- f. Center line: a long-short-long line used to depict the center of a round object.
- g. Leader line: a solid line with an arrow pointing from an explanatory note to a specific feature of an object.
- h. Break line: a solid, zigzag line which indicates that part of the object being drawn is not fully illustrated or has been left out.

4. Developing the Views

- a. Choose an appropriate scale which will allow all views to fit within the border lines.
- b. Locate and mark off the spaces for the various views.
- c. Establish the main lines of the drawing, then add the minor ones.
- d. Develop all the views together. In a three-view, orthographic drawing, project from the front view to the top and end views with the T square and triangles.
 - 1) Use the T-square against only the left edge of the board for drawing horizontal lines, since the board may not be perfectly square.
 - 2) Use a right-angle triangle with the T-square to draw vertical lines.
- e. Finally, add the dimension lines and notes.

ACTIVITY:

1. Make a freehand sketch of a simple shop project. Engineer's paper can be used.
2. Develop an orthographic (3-D) drawing from the sketch of the project.

PROJECT PLANNING & CONSTRUCTION

A. Project Planning Considerations

1. Will the project be subject to loads or weights such that strength considerations must be taken into account?
 - a. Strength is important when planning a ladder or ramp, but it is not as critical a factor when planning a decorative lamp stand.
2. Are suitable materials, tools, and fasteners readily available?
 - a. If building a project that needs to be arc welded, is the appropriate type (AC, DC, MIG, TIG) and size of welder available along with the correct size and type of welding rod?
3. Is there a similar part or item commercially available which would eliminate the need to "reinvent the wheel."
 - a. For example, if planning to build an engine stand, check commercially available models to get ideas regarding design, size, and types of materials used, as well as joint types.
4. Use standard size, commercially available parts and components to hold down expense and excessive fabrication time and costs.
 - a. It will cost more and require more fabrication time to specify 1/8" X 1-1/16" strip steel (NOT commercially available) rather than 1/8" X 1" strip steel which is commercially available.
5. Consider set-up and jiggling techniques to eliminate "impossible" or extremely difficult fabrication and assembly.
 - a. When sketching or laying out plans, consider what the sequence of procedures should be in order to complete all the steps in the simplest and most efficient way.
6. When appearance is not a consideration, use less expensive materials.
 - a. Use hot rolled steel in place of cold rolled steel because the cost of hot rolled steel is less and the strength is the same even though the appearance is slightly less shiny.
 - b. Use economical grades of lumber for general utility and construction projects.

B. Interpreting Working Plans

1. Cutting List

- a. A cutting list itemizes the various dimensions of materials (wood, metal, etc.) that must be cut before being assembled.
- b. This tabular form includes the name of the project part, the number of pieces, the dimensions, and the type of material.
- c. This list serves as a checklist of project parts required for assembly and speeds up the construction process by alerting the builder to set up cutting jigs for project parts having the same dimensions.
- d. If a plan has no dimensions specified, but is drawn to scale, use an architect's scale to determine the dimensions required.

2. Bill of Materials (for more information look at Curriculum Section 130-I)

- a. A bill of materials is a list of all the materials needed for a project with the total cost calculated.
- b. This tabular form includes the number of pieces, the dimensions, a description of the items, the cost per unit, and the total cost.
- c. It is preferable to order standard stock sizes that will provide the desired materials with the least possible waste.
- d. List similar materials together and in the order they will be used.

C. Project Layout & Construction

1. Study the working drawing to understand which parts must be assembled first and in what sequence.
2. Construct jigs to speed up the assembly of duplicate parts (such as trusses).

ACTIVITY:

1. Have student draw the project on page 130D-10.
2. Calculate the construction cost of a project by making a bill of materials from a working drawing. A bill of materials form may be obtained from Section 130-I of the agricultural mechanics curriculum
3. Complete a cutting list from a working drawing of a project.
4. Use the drawing provided (130D-10) to construct a flywheel puller. Hole sizes and spacing will be determined by the flywheel and shaft, spacing should be equal.
5. Lay out and assemble a simple project. This may be coordinated with the unit on woodworking, welding, plumbing, or metalworking.

Special Material and Equipment:

A working drawing for the project to be constructed and the tools and materials required. Architect's scale or ruler, pencils, paper, drawing board, T square, 45 degree triangle (8" long sides), 30 degree X 60 degree triangle (10" side), cross-ruled paper, tracing vellum

References:

Burke, Stanley R., & Wakeman, T. J. (1990). MODERN AGRICULTURAL MECHANICS (2nd ed.). Danville, IL: Interstate Publishers.

Cooper, Elmer L. (1987). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS. Albany, NY: Delmar Publishers.

Jones, M. M. (1955). SHOPWORK ON THE FARM (2nd ed.). New York: McGraw-Hill.

Spencer, H. C., & Dygdon, J. T. (1980). BASIC TECHNICAL DRAWING. New York: Macmillan.

Resources:

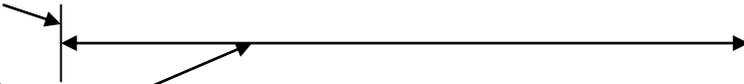
Bear, W. F., Hamilton, W. H., & Mann, A. (1974). PLANNING PROJECT CONSTRUCTION. Available from Hobar Publications, 1234 Tiller Lane, St. Paul, MN 55112, (612) 633-3170

BASIC LINES USED IN DRAWING AND SKETCHING

Border Line 

Object Line 

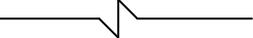
Hidden Line 

Extension Line 

Dimension Line 

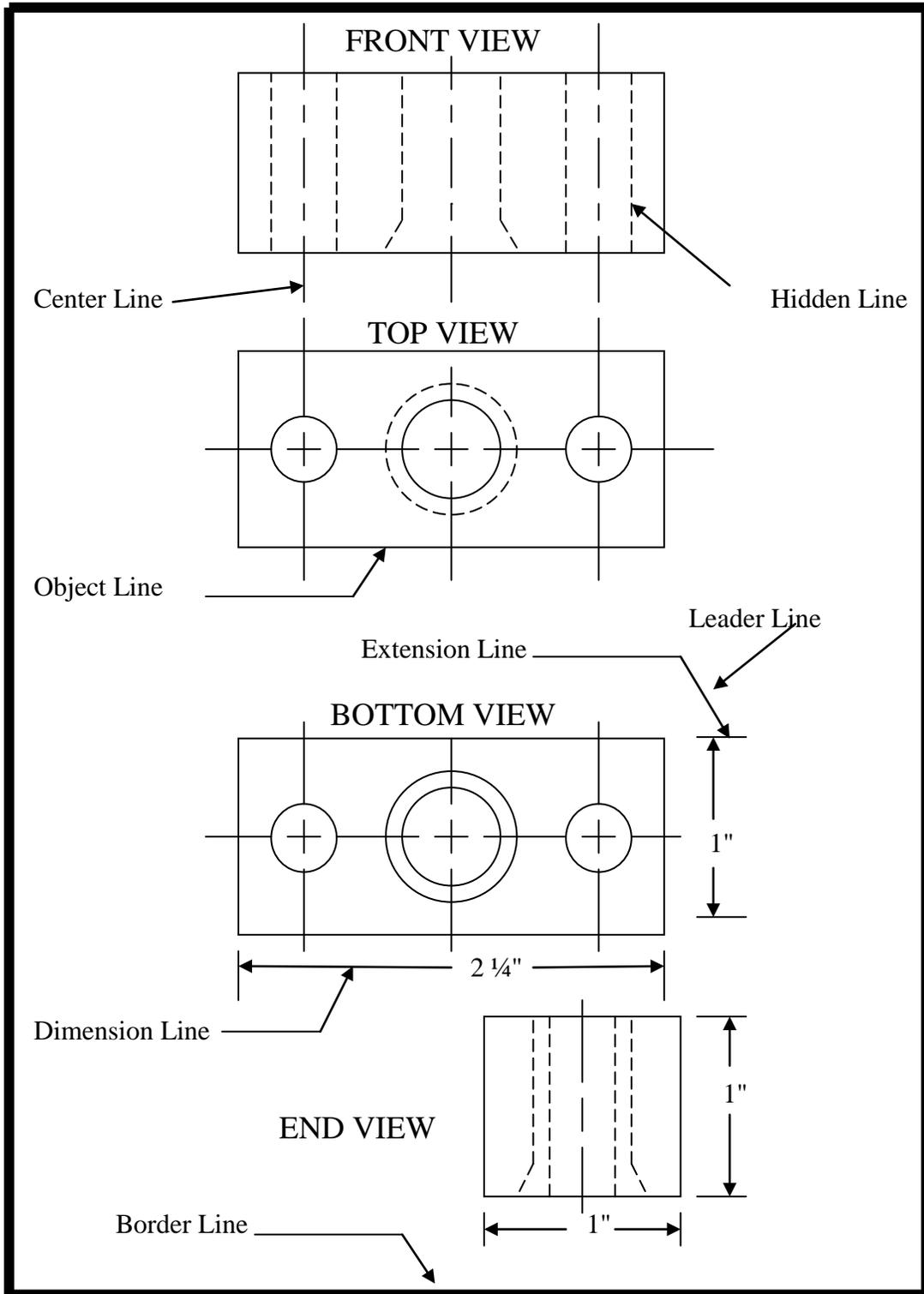
Center Line 

Leader Line 

Break Line 

130D-10

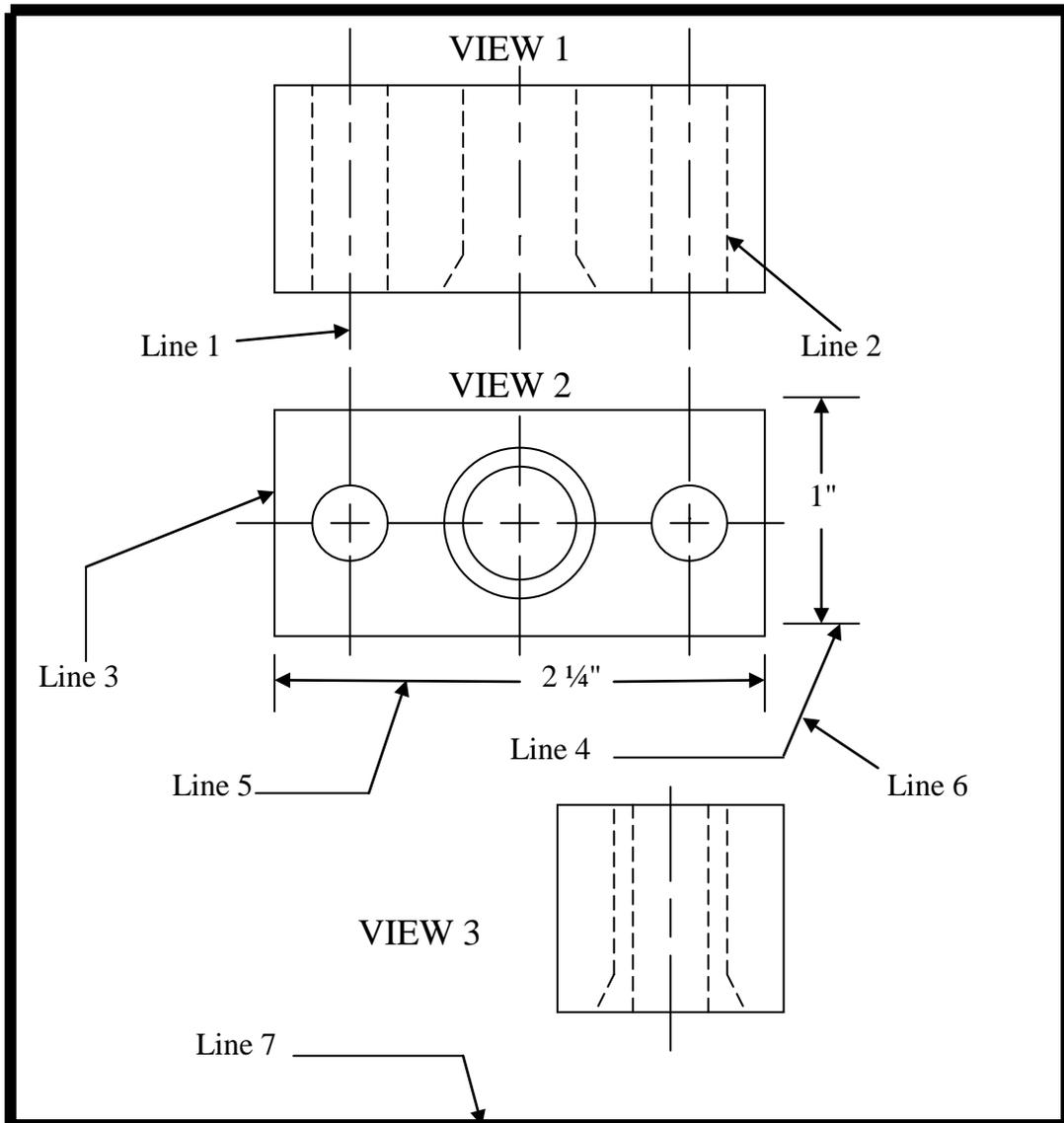
FLYWHEEL PULLER



DRAFTING WORKSHEET

Identify and name the following Views and Lines

- 1. View 1 _____ View 2 _____ View 3 _____
- 2. Line 1 _____
- 3. Line 2 _____
- 4. Line 3 _____
- 5. Line 4 _____
- 6. Line 5 _____
- 7. Line 6 _____
- 8. Line 7 _____



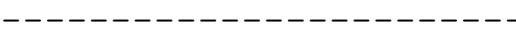
DRAFTING, EXAM

Answer the following questions 1 – 5, matching.

1. Border Line _____

A. 

2. Leader Line _____

B. 

3. Center Line _____

C. 

4. Hidden Line _____

D. 

5. Object Line _____

E. 

Fill in the Blanks and Short Answer

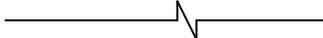
6. Name the three views on orthographic drawings.

_____, _____, _____.

7. What is a sketch?

8. What is a working drawing?

9. Name one safety practice used in making a drawing.

10. What does the Broken Line indicate? 

11. Name three items you will find in a title block.

_____, _____, _____.

12. Name two things to consider when planning a project.

_____, _____.

13. What tool is used to measure lines?

14. What drawing instrument is used to make horizontal lines.

15. What drawing instruments are used to make vertical lines?

Exam, Answer Sheet

1. D
2. A
3. E
4. B
5. C

6. Front, Side, End
7. Sketches are freehand drawings of an object for a project done in order to get an idea down on paper.
8. Working drawing are complete drawings done in universal graphic language so that the object depicted can be constructed from the drawing alone with out additional information.
9. Name one of the four. 1, Store sharp-pointed drawing instruments stored in their case. 2, Place drawing instruments in a safe place to prevent falling. 3, Fasten the drawing tabletop securely before you start to draw. 4, No playing with sharp-pointed drawing instruments.
10. Indicates that part of the object being drawn is not fully illustrated or has been left out.
11. Name of the person who doing the drawing, the date, and title of the drawing.
12. Name two of the five. Strength, Suitable Materials, Don't reinvent the wheel, Use standard sizes, Sequence of procedures.
13. Ruler or architects scale
14. T-square
15. T-square and a 90* triangle

Worksheet, answers

1. 1, Side View 2, Bottom View 3, End View
2. Line 1 – Center Line
3. Line 2 – Hidden Line
4. Line 3 – Object Line
5. Line 4 – Extension Line
6. Line 5 – Dimension Line
7. Line 6 – Leader Line
8. Line 7 – Border Line

130E-1

TOOL SAFETY, USE AND IDENTIFICATION

AG130E

UNIT OBJECTIVE

After completion of this unit, students will be able to identify the importance of tool identification and safe tool use in the agricultural mechanics industry in the United States, Idaho, and the local community. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Identify all the tools listed in the AG 130 CURRICULUM GUIDELINES unit on tool & hardware identification.
2. Demonstrate the proper and safe use of the tools to be used in the agricultural mechanics program.
3. Use tools properly and safely.

TOOL IDENTIFICATION, SAFETY AND USE

A. Introduction

1. Accidents occurring in the agricultural mechanics shop often occur because students do not have a basic understanding of shop procedures, rules of conduct, and general shop safety. The purpose of this lesson is not only to identify many of the power tools used in the shop, but also to provide students with proper operating procedures and safety techniques involved with each lab.

B. Woodworking Power Tools

1. Circular Saw - The circular saw is the most useful of all woodworking machines. It can be used for crosscutting, ripping, mitering, beveling, chamfering, rabbeting, cove cutting, tapering, shaping, and molding cutting. This tool is used in situations where the work cannot be moved to the shop or in a shop where table saws are not available. Circular saws come in a variety of blade sizes ranging from 6 1/4" to 8 1/2."

a. Operating Procedures for the Circular Saw

- 1) Secure the material to be sawed in a vise or with clamps to the work table.
 - 2) Mark the line of cut with a pencil.
 - 3) Install the proper blade suited to the material being cut.
 - 4) Grasp the saw firmly with both hands. Start the saw and allow the blade to reach full operating speed before making contact with the material being sawed.
 - 5) Allow the saw to move at its own rate through the wood. Do not force the saw.
 - 6) Protect the electrical cord from the line of the cut.
 - 7) Always use both hands to hold and guide the saw.
 - 8) Clear away scraps of wood on the table only after the saw stops running.
2. Band Saw - The band saw is a useful wood cutting tool which has an endless blade traveling around two wheels. Size is determined by blade diameter.

a. Types of Band Saws

- 1) The mill band saw is used for sawing logs into lumber.

130E-3

- 2) The re-saw type is used to saw thick stock into thin stock.
- 3) The small band saw is used to saw straight and curved cuts in wood.

b. Adjusting the Band Saw

- 1) Remove the wheel guards and table insert. Loosen the guide pins and blade-support rollers.
- 2) Loop the desired blade through the slot in the table and around the tapered bottom wheels. Make sure the teeth are pointing down through the table.
- 3) Adjust the tilting screw of the top wheel until the top wheel is in line with the bottom wheel.
- 4) Tighten the tension screw.
- 5) Adjust the top guide until the front edges of the guide rollers are just behind the saw teeth. The teeth must never run between the guide rollers.
- 6) Rotate the wheels to see if the saw is properly adjusted. Replace all safety guards.
- 7) Turn the saw on and off to see if it has been properly adjusted.

c. Operating Procedures for the Band Saw

- 1) Always mark the material to be cut.
- 2) Use a thin blade for sawing curves and a thick blade for re-sawing, cross cutting, and ripping.
- 3) Allow the blade to set the pace of the cut. Do not force the material into the blade.

d. Safety Precautions when using a Band Saw

- 1) Wear safety glasses.
- 2) Use a push stick when sawing small wood stock.
- 3) Never use cracked or kinked saw blades.
- 4) Never twist the blade when sawing curves.
- 5) Try to avoid backing out of a cut, because this can bind and break the blade.
- 6) Keep fingers clear of the moving blade.
- 7) Stop the saw before removing scraps.

3. Portable Electric Saw - The portable electric saw is a combination of circular saw and a power hand saw. It can be used for ripping, or crosscut sawing. The portability of this saw makes it a valued tool in construction and repair work. The portable electric saw can be used with attachments to perform the same jobs as a table circular saw and a radial arm saw.

a. Operating Procedures for the Portable Electric Saw

1) The operating procedures for the portable electric saw are the same as those for the circular saw.

b. Safety Precautions when using a Portable Electric Saw

- 1) Do not use dull or worn blades.
- 2) Bring the saw to full speed before cutting and push the saw slowly and steadily into the work.
- 3) Do not reach over or around a saw that is running.
- 4) Do not use the saw in awkward positions.
- 5) Keep all parts of the body away from the blade while it is in operation.
- 6) Keep the cord away from the blade to prevent electric shock.

4. Cut-off or Radial Arm Saw - The radial arm saw is used to cut long pieces of wood down to a more usable size. The advantage of a radial arm saw is that the work remains stationary when cross cutting, and the saw comes down onto the work instead of up into it. This eliminates the awkward process of pushing long pieces of lumber across the saw table.

a. Operating Procedures for the Radial Arm Saw

- 1) Set the blade depth at a length that penetrates the width of the work but does not saw through the baseboard.
- 2) Brace the work against the fence, which acts as a support on the baseboard.
- 3) Start the saw and bring it to full working speed.
- 4) While bracing the work with one hand, pull the saw body across the work, keeping both hands clear of the blade.
- 5) Place the saw back in its starting position. Turn the saw off and wait for the blade to stop before removing work pieces and set-ups.

- 6) For ripping, the saw motor must be locked parallel to the fence.
- 7) The work is pushed through the saw with a procedure similar to that of a circular saw. Always push the work into the saw from the direction indicated on the saw guard. If fed from the rear, flying wood chips may injure the operator.

b. Safety Precautions when using a Radial Arm Saw

- 1) Always wear a face shield or safety goggles.
- 2) Hold the work firmly against the fence.
- 3) Stand to one side of the direction of the blade and keep hands and body parts away from the blade.
- 4) Feed the saw into the wood only as fast as it will easily cut.
- 5) Never cut more than one piece of stock at a time.
- 6) Return the saw to the beginning position, turn the power off, and wait until the blade has completely stopped before removing scraps of the work material.

5. Jigsaw (also called the scroll saw) - The jigsaw has a short blade that moves up and down, cutting only on the down stroke. The scroll saw is used for cutting curves and fine detail in thinner stock. It can also be used to cut light metal and plastic.

a. Operating Procedures for the Jigsaw

- 1) Mark the line of the cut with a pencil.
- 2) To cut center sections of the material, drill a hole in the work, disconnect the blade and pass it through the hole, and then reconnect it.
- 3) Start the saw and feed the material with gentle pressure along the pencil marks.
- 4) When starting at the edge of the material, simply feed the material with light pressure through the saw blade.

b. Safety Procedures when using a Jigsaw

- 1) Wear a safety shield or goggles.
- 2) Keep hands and body parts away from the moving blade.
- 3) Never feed the material faster than the saw can easily cut. The jigsaw blade is thin and can easily break.

130E-6

- 4) Check the blade for proper adjustment and alignment before starting in order to prevent broken blades.

6. Saber Saw - The saber saw is simply a portable jigsaw. It is also referred to as a sabre or bayonet saw. The saber saw can be used to cut plastics, wood, fiberglass, plexiglass, and thin metals.

a. Operating Procedures for the Saber Saw

- 1) Secure the work to be sawed to a bench or table.
- 2) Mark the line of the cut with a pencil.
- 3) Place the edge of the blade against the material before starting. With all other saws, the blade is brought to speed before touching the material.
- 4) Start the motor and feed the blade through the work. Allow the blade to cut at its own rate.
- 5) When cutting interior sections of the material, drill a hole and place the saw blade through the hole before starting.

b. Safety Precautions when using a Saber Saw

- 1) Wear a face shield or safety goggles.
- 2) Remove all nails, staples, and loose knots from the material.
- 3) Do not force the blade through the material.
- 4) Keep hands clear of the blade.
- 5) Protect the electrical cord from the blade.

7. Planer or Surfacer - The planer is used to plane boards smooth to an even thickness.

a. Parts of the Planer or Surfacer

- 1) Planer knives are mounted on the revolving cutter-load. There are usually 24 to 27 knives in each planer. The rotating knife blades remove material from the wood that is passed over it.
- 2) Planer Bed - The planer bed is the flat support that guides the wood over the blades.
- 3) Pressure Bar - The pressure bar holds the lumber down on the bed rollers and keeps the end of the board from being dropped out as it leaves the cutter head.

- 4) Feed Rollers - The two spring rollers operate under spring compression and feed the lumber through the planer.
- 5) Chip breaker - The chip breaker breaks the chips off near the cutter head and deflects them over it; this prevents chip buildup near the blade which will result in uneven cutting or tearing of the wood.
- 6) Material Thickness Gauge - The material thickness gauge indicates the exact thickness to which the material will be surfaced or planed.

b. Operating Procedures when using the Planer

- 1) Set the material thickness gauge to the desired dimension.
- 2) When surfacing several pieces of lumber with varying thicknesses, sort the lumber into piles according to the thickness and plane down until even. This will require fewer adjustments to the surfacer and result in less variation of the final product.
- 3) Feed the lumber through several times while turning the board over each pass. This will insure even planing.
- 4) Continue passing the boards through until one side is smooth and the desired thickness is reached.

c. Safety Precautions when using a Planer

- 1) Wear a safety shield or goggles.
- 2) Wear hand protection.
- 3) Keep the face and body clear of the feed roll area to prevent injury from flying splinters.
- 4) Remove all knots, nails, and staples from the wood before planing.
- 5) Keep the planer knives sharpened and properly adjusted.
- 6) Keep hands at a safe distance from the moving parts in order to prevent them from getting sucked into the blades.
- 7) Wear hearing protection when operating or working near the planer.

8. Jointer - The jointer is similar to a planer in that it is used to smooth a surface of a board. It can also be used to square an edge, bevel, or chamfer.

a. Operating Procedures for the Jointer

- 1) Adjust the front and rear tables to the same height. If improperly adjusted, a smooth cut is impossible.
- 2) Adjust the fence, which acts as a feed guide and angle indicator.
- 3) Adjust the knives to the desired height to prevent chipping and tearing. The blades should not be raised more than 1/16" above the tables.
- 4) Place the edge of the lumber on the front table. Apply sideways and downward pressure to hold it flat and against the fence.
- 5) Run the board through the jointer.
- 6) To use the jointer to bevel wood:
 - a) Use a T-bevel to set the fence at the desired angle.
 - b) Set the front table to the desired depth of the cut.
 - c) Press the board down and against the fence while pressing over the jointer blades.
- 7) To use the jointer to rabbet boards:
 - a) Rabbeting is a process used to make lap joints in boards.
 - b) Adjust the depth of cut to half the thickness of the board.
 - c) Remove the front guard.
 - d) Set the fence 1/2" from the left end of the cutting blades.
 - e) Pass both boards over the jointer.
- 8) To use the jointer for tapering:
 - a) Divide the board into equal lengths of 6" or 8."
 - b) Set the blade height to plane the first section.
 - c) Plane the first section and readjust the jointer blades. Continue this procedure for the length of the board.
 - d) Even the taper using a hand plane.

b. Safety Precautions when using a Jointer

- 1) Wear a safety shield or goggles.
- 2) Use a push block to move the wood across the jointer.
- 3) To prevent injury from the blades never joint lumber less than 10" long.
- 4) Joint with the grain to prevent splinters.
- 5) Keep the knives sharp and properly adjusted.
- 6) Use the fence to support the stock.
- 7) Keep hands away from the cutter-head; never pass hands directly over the cutting head.

9. Shaper - The shaper is used to cut specialized shaped edges, moldings, and picture frame stock. Safety should be stressed while using the shaper because wood is fed directly into a rotating, exposed blade.

a. To shape straight edges:

- 1) Adjust the fence of the shaper to the desired depth of the cut.
- 2) Select and install the desired cutting bit.
- 3) Start the shaper and run the board along the fence, holding it securely with hands to the side of the board away from the blade.
- 4) Run the board along the fence smoothly and quickly to avoid burning the wood.

b. To shape curved pieces of wood, remove the fence and follow the same procedure. The wood can still be burned or scored if passed too slowly across the blade.

c. Test the setup on a sample piece of wood before shaping the project material.

d. Safety Precautions when using a Shaper

- 1) Wear a face shield or safety goggles.
- 2) Make sure the stock is free from loose knots, cracks, or other defects.
- 3) Use the fence whenever possible.
- 4) Use a push stick whenever possible.
- 5) Push all work opposite to the direction of the rotation of the cutter.
- 6) Keep hands well away from the revolving cutters.
- 7) Turn the power off and wait until the cutter has stopped before removing shavings.

10. Router-Shaper - The router is a portable shaper that moves over the work instead of the work being moved through the blade.

a. Operating Procedures for the Router

- 1) Secure the work in a vise or with clamps to a work bench.
- 2) Mark the area to be routed with a pencil.
- 3) Select the desired router bit and router guide and attach securely.
- 4) Grasp the router firmly with both hands.
- 5) Bring the bit to full running speed and slowly ease into contact with the wood.
- 6) The bit will pull itself along the cut. Move the router from the left to the right for the cleanest cut.

b. Safety Procedures when using a Router

- 1) Fasten the bit securely to the chuck. The bit should be at least 1/2" into the chuck.
- 2) Wear a face shield or safety goggles.
- 3) Be sure the switch is in the off position before plugging in the electrical cord.
- 4) Hold the machine firmly with both hands.
- 5) Keep hands clear of the cutting bit.
- 6) Turn the power off and wait until the blade has stopped rotating before resting it on its side.

11. Sanding Machines - There are many types of power sanders including disc, belt, drum, spindle, and sheet sanders. Power sanders use abrasive paper or cloth that spins at high speeds to remove material from the project stock. Sanders can come attached to a stand or as a variety of possible electric models.

a. Belt Sanders - The belt sander is the most powerful sander. It is used to strip paint and varnish, remove corrosion and rust, polish surfaces, or remove a large amount of material as quickly as possible.

1) Operating Procedures for the Belt Sander

- a) Secure the material to a vise or to a workbench.
- b) Place one hand on the front knob and the other on the rear handle.

- c) Use the rear hand to press the starter trigger. Bring the belt to full working speed before making contact with the work.
- d) Touch the heel of the sander to the work and then ease the entire belt surface onto the wood.
- e) Use back and forth, and sideways motions to evenly sand

b. Finishing Sanders - The finishing sander is used for minor sanding and touch-up jobs. The two types of finishing sanders are straight line movement and orbital. Straight line sanders move back and forth while orbital movement is circular; dual-motion sanders are also available.

1) Procedures for Replacing Sandpaper Sheets or Spring

- a) Lift the front clamp and insert the sandpaper end in until it meets the posts and is even with the plate.
- b) Release the lever and press down firmly.
- c) Fold the paper over the base plate and under the clamp. Draw the paper as tightly as possible and lift the rear clamp. Insert the other end of the paper squarely, release the lever, and press down firmly.

2) Procedures for Replacing Abrasive Paper on Knurled Roller Sander

- a) Insert the abrasive paper between the roller and the top of the base plate.
- b) Turn the roller with a screwdriver while holding the paper edge against the knurled roller.
- c) Fold the paper under the plate.
- d) Repeat the operation for the rear roller.
- e) Draw the paper as tightly as possible.

c. Disk Sanders - A disk sander is simply an abrasive paper attachment that is used on portable grinders. Disk sanders are best for paint removal, coarse shaping, and rough sanding. The high speed of the disk sander can cause gouges and chips; consequently, it is not recommended for finish work.

- d. Contour Sander - The contour sander is used on irregular and curved surfaces. The contour sanding attachment can be used on motor shafts, lathe chucks, drill presses, and electric drills.
- e. Safety Precautions when using Power Sanders

- 1) Wear a safety shield or goggles.
- 2) Check the condition of the abrasives.
- 3) Wear a respirator where no catch bag is available to reduce dust.
- 4) Never touch the moving abrasives.
- 5) Bring the sander to working speed before coming into contact with the work. Remove the sander from the work before stopping the sander.

- 12. Wood Turning Lathe - The wood lathe is used to shape wood into various round, cylindrical shapes. The wood is spun at a high rpm while the operator shapes it with various hand tools.

- a) Operating Procedures for the Wood Turning Lathe

- 1) With a punch or awl mark the dead center on both ends of the wood stock to be used.
- 2) Embed the centers into the dead center of the wood. Use oil or beeswax to lubricate the center before inserting.
- 3) Clamp the tailstock firmly in place.
- 4) Turn the rough stock one revolution by hand.
- 5) Start the lathe at the lowest speed.
- 6) Adjust the tool rest to 1/8" from the rough stock. Use a gauge to rough the wood to round form. Start 2" from the tail stock and work forward.
- 7) Increase the speed to 2,400 - 2,800 rpm's and use various handtools to reach desired shape. Always keep the tool rest 1/8" from the wood.
- 8) Remove the tool rest to sand at high speeds.

- b) Safety Precautions for the Wood Turning Lathe

- 1) Wear a safety shield or goggles.
- 2) Make sure the stock is free from loose knots, nails, or other defects.
- 3) Be sure stock is properly mounted and secured to the lathe.
- 4) Make sure the tool rest is properly adjusted and clamped securely.

- 5) Do not shift belt or belt-driven lathe to a different speed while running.
- 6) Hold turning tools firmly against the rest with both hands.
- 7) Never touch the stock while it is revolving.
- 8) Stand to one side when the power is first turned on.

13. Mortiser - The mortiser is used solely for making mortises. A drill attachment can also serve the same purpose. Mortises are required on doorjams and in specially built furniture. Chisel bits are inserted into the mortise chuck to cut different size mortises.

a) Operating Procedure for the Mortiser

- 1) Select a chisel and place it in the casting. Slightly tighten the setscrew.
- 2) Push a mortising bit up through the hollow chisel. Tighten the assembly.
- 3) Turn the feed lever down, and lock the quill in its lowest position.
- 4) Adjust the fence so that the chisel and fence are square with each other.
- 5) Cut the mortise by evenly pushing the chisel onto the wood.

b. Safety Precautions when using a Mortiser

- 1) Clamp all stock securely to the table.
- 2) Wear a face shield or goggles.
- 3) Keep hands away from the chisel when the machine is turned on.
- 4) Feed the chisel only as fast as the machine will easily cut.
- 5) Lift the bit clear of the mortise before moving table.

C. Metalworking Tools

1. Bar Folder/Brake - The bar folder and the brake are used to bend and fold a variety of metal stock and to bend sheet metal. The procedures for using the tools varies depending upon the size of the metal used, the type of bend desired, and the angle of the bend. Read the manufacturer's directions for operating procedures.

a. Safety Precautions when using a Bar Folder/Brake

130E-14

- 1) Keep hands clear of movable parts.
 - 2) Remove all sharp burrs and edges from the metal before folding.
 - 3) Fold only single thickness of sheet metal within the capacity of bar folder or the brake.
 - 4) Let the bar down slowly after completing the bend.
2. Metal Shear - The metal shear is used to cut large pieces of sheet metal. Bench shears come in different sizes, the most common shop size being a 30" shear with a 7" cut.

a. Operating Procedures for the Metal Shear

- 1) Lift the top handle and feed the metal through the front.
- 2) Push the top handle down with both hands through the sheet metal.
- 3) Use the guide to cut straight strips of metal.

b. Safety Precautions when using a Metal Shear

- 1) See that all guards are in place.
- 2) Stand directly in front of the machine.
- 3) Keep fingers away from the clamp and blade.
- 4) Cut only single pieces of metal.

3. Bench Grinder - The bench grinder is a motor driven wheel made of various abrasives. It is used to remove or polish the metal. Different grinding wheels are installed depending on the job to be performed or the amount of material to be removed.

a. Operating Procedures for the Bench Grinder

- 1) Adjust the tool rest to no more than 1/8" from the grinding wheel. The tool rest should be no closer than 1/16" from the wheel.
- 2) Start the grinder while standing to the side of the wheel.
- 3) Grasp the object to be ground firmly in both hands.
- 4) Slowly move the tool to the moving grinding wheel while supporting it on the tool rest.

b. Safety Precautions when using a Bench Grinder

- 1) The tool rest must be properly set at 1/16" to 1/8" from the wheel to prevent the wheel from pulling the tool down between the tool rest and the wheel.
- 2) Wear a safety shield or goggles even if the grinder is equipped with a face shield.
- 3) Keep hands away from the shield when it is in motion.
- 4) Do not wear loose clothing or gloves near the wheel.
- 5) Grind only on the face of the wheel; grinding on the side may cause the wheel to break.

4. Buffer - The buffer is used to polish metal. A buffing wheel is attached to a bench or portable grinder.

a. Operating Procedures for the Buffer

- 1) See operation procedures for the bench grinder.
- 2) A buffing compound is generally applied to polish the material being buffed.

b. Safety Precautions when using a Buffer

- 1) Wear a safety shield or goggles.
- 2) Apply compound sparingly.
- 3) Keep hands away from the wheel when it is in motion.
- 4) Buff flat surfaces from the center toward the lower edge. All sharp edges should point downward when being buffed.

5. Portable Grinder and Disk Sander - The portable grinder and disk sander are useful tools for removing excess material from objects that are too large or too heavy to place on a bench grinder.

a. Operation Procedures for the Portable Grinder and Disk Sander

- 1) Secure the object to be ground in a vise or to a table with a clamp.
- 2) Hold the grinder firmly with one hand on the handle and the other on the body and trigger.
- 3) Hold the grinder away from the body and start it, bringing it to full speed.
- 4) Ease the grinder wheel to the project. The wheel face should be flat on the project.

- 5) Angle the grinder so that the sparks fly away from the operator.
- 6) Use a circular or a side-to-side and up-and-down motion to remove the metal.

b. Safety Procedures when using a Portable Grinder or Disk Sander

- 1) Use the face of the wheel only. Grinding with the edge may cause the wheel to shatter.
- 2) Always use both hands to support the grinder or disk sander. The tool rotates at high rpm's and can fly from the project if not properly supported.
- 3) Wear a safety face shield, gloves, and a long sleeve shirt for protection from flying sparks and metal fragments.
- 4) Make sure no one is within a distance where they can be hit by the sparks.
- 5) Allow the grinding wheel or disk to come to a complete stop before setting it down on its side.
- 6) Do not touch the metal immediately after it has been disked or ground. The abrasive action will heat the metal.

6. Metalworking Lathe - The lathe holds and rotates the work while it is being shaped by a cutting tool that is fed against the work. Metalworking with a lathe requires much more precise measurement than woodworking. Measurements must be accurate to the thousandths of an inch. Therefore, a micrometer and a set of calipers is required for accurate measurements.

a. Operating Procedures for the Metalworking Lathe

- 1) Determine the dead center of each end of the metal to be lathed. A pair of dividers or a center head can be used for this purpose.
- 2) Use a center punch to mark the centers. If the initial punch is not accurate, the center punch can be driven at an angle to move the drilling hole.
- 3) Drill both ends of the metal. The drill holes should fit the lathe center perfectly to insure the correct true of the metal.
- 4) Use oil or grease in the drilled holes and attach the metal stock to the lathe using the lathe centers.

- 5) Mount the cutting tool in the tool holder and the tool holder in the tool post. Mount the tool holder in the tool post so that in case it slips, it will swing away from the work and not gouge.
- 6) Set the cutting depth using a micrometer.
- 7) Turn the machine on. Make a light trial cut that is shallower than the setup for thread cutting.
- 8) If accurate, adjust the tool holder to make the actual cut.

b. Safety Procedures when using a Metalworking Lathe

- 1) Wear safety shield or goggles.
- 2) Avoid loose clothing and tie back long hair that may get caught in the lathe.
- 3) Start the lathe at a slow speed while standing away from the direction of the rotation.
- 4) Never touch the metal while it is rotating.
- 5) Never remove scraps while the lathe is in operation.
- 6) Keep fingers and hands away from all moving parts.

7. Milling Machine - The milling machine is very useful in cutting and shaping metal. Metal is removed by a rotating multi-tooth cutter that is fed into the work.

a. Operating Procedures for the Milling Machine

- 1) Seat the work against the parallels on the machine or the bottom of a vise using a mallet or a soft hammer.
- 2) Securely fasten the work.
- 3) Set the milling machine for the proper cutting depth.
- 4) Disengage all handles if the machine has an automatic feed.
- 5) Turn the machine on and make sure it is turning in the proper direction.
- 6) Feed against or opposite to the direction of rotation of the cutter.
- 7) Release the automatic feed after the machine has been turned off and has stopped.

b. Safety Precautions when using a Milling Machine

- 1) Wear a safety shield or goggles.
- 2) Make adjustments to the machine only when it is at a dead stop.

- 3) Be sure the work is securely fastened.
 - 4) Stand to one side of the machine when starting.
 - 5) Use a brush to remove chips. Never use a hand or blow the chips clear. The chips are sharp and may cut the hand or eye.
 - 6) Keep hands clear of moving parts.
8. Oxygen-acetylene Welding - Welding is useful for joining metals together. The oxyacetylene system combines oxygen and acetylene gas to produce extreme heat that fuses the metal together.
9. Arc Welding - The arc welding machine uses electric current to weld metal together.
10. Spot Welder - Spot welding is known as resistance welding. The weld is produced by heat obtained from the resistance of the work to a flow of electric current and the application of pressure. Spot welding is frequently used in agriculture to weld sheet metal parts. It is a fast method of welding light gauge metals and produces a clear, uniform, and strong weld. It is an easier, safer, and more accurate method of welding than either arc or oxyacetylene welding.

D. Tools used in Both Woodworking and Metalworking

1. Drill Press - The drill press is a stationary machine used to drill holes. If used with attachments, the drill press can also be used for boring, routing, and mortising.
 - a. Operating Procedures for the Drill Press
 - 1) Set the speed of the drill, according to the diameter of the bit.
 - 2) Select the drill bit and chuck to use. Place the chuck in the drill.
 - 3) Insert the drill bit and tighten with the chuck key.
 - 4) Align work under the bit. Clamp the work securely.
 - 5) Start the drill and bring it to full working speed.
 - 6) Lower the bit using the pilot wheel feed. Do not force the bit through the metal. Use cutting oil on thick pieces of metal. Allow the bit to cut at its own speed.
 - 7) After the bit has gone through the material, release the pilot wheel feed and turn the machine power off.

b. Safety Precautions when using a Drill Press

- 1) Shift belt and make other adjustments only when the power switch is off.
- 2) Be sure that the belt guard is in place.
- 3) Secure the work to be drilled. Use a drill press or vise when possible.
- 4) Remove the chuck key immediately after using it.
- 5) Wear a safety shield or goggles.
- 6) Never wear loose clothing or gloves or allow long hair to be near the drill bit when turning.
- 7) Stop the drill press before attempting to remove work, chips, or cuttings.

2. Portable Hand Drill - The hand drill is used to drill holes into different material. Portable hand drills are made in various sizes and vary in power from light to heavy and in speeds from slow to fast.

a. Operating Procedures for the Portable Hand Drill

- 1) Select the bit to be used, insert it into the chuck, and tighten with the chuck key.
- 2) If drilling metal, use a center punch to indent the point of the hole to be drilled.
- 3) Holding the drill firmly, bring it to full working speed.
- 4) Ease the bit towards the work. Do not force the bit.
- 5) After breaking through, immediately back off on the pressure.
- 6) Remove the drill from the hole and release the trigger or power switch.

b. Safety Precautions when using a Portable Hand Drill

- 1) Wear a safety shield or goggles.
- 2) Remove the chuck key immediately after using it.
- 3) Make sure the drill is grounded either internally or with a ground wire to the outside of the drill.
- 4) Always hold the machine firmly.
- 5) Keep hands away from the revolving drill bit. Never wear loose clothing or gloves that may become entangled in the bit.
- 6) Apply straight and steady pressure. Do not force the drill bit. It may break and injure the operator.

130E-20

- 7) Ease up on the pressure just before the drill begins to break through the material.
- 8) Turn the power off and allow the machine to come to a complete stop before putting it down.

E. Additional Shop Equipment

1. Forges and Furnaces - Gas and electric furnaces and coal forges create very high temperatures in order to heat metal for shaping.

a. Operating Procedures for the Forge and Furnace

- 1) Consult the manufacturer's directions for operation procedures of forges and furnaces.

b. Safety Precautions when using a Forge or Furnace

1) Gas Furnace

- a) Check for gas leaks.
- b) Light the furnace while standing to one side and with the doors open.
- c) Use tongs to remove metal from the furnace.
- d) Use a flint lighter and not materials to light a gas furnace.
- e) Wear a face shield or safety goggles.

2) Electric Furnace

- a) Be certain the furnace is properly grounded and the cable is insulated to prevent electrical shock.
- b) Remove all scale from the furnace grating. The scale can short and burn out the electric coils.
- c) Use tongs to remove hot metal from the furnace.

3) Coal Forge

- a) Keep the area around the forge clean.
- b) Use tongs to remove hot metal from the forge.
- c) Wear a face shield or safety goggles.

2. Storage Battery - Extra batteries are often used in the shop for faster service of tractors and other farm equipment. These batteries should be regularly serviced and charged even when not being used.

a. Servicing Procedures for the Storage Battery

1) Use a hydrometer to test the charge of the battery.

- a) Remove the cell caps from the battery.
- b) Hold the hydrometer tube vertical and suck in a small amount of electrolyte.
- c) Read the hydrometer with the electrolyte at eye level.
- d) Add distilled water if the electrolyte level is low.

2) Charging the Battery

- a) Remove all cell covers.
- b) Provide ample ventilation.
- c) Connect the positive and negative lead wires to the respective battery terminals.
- d) Set the charge setting.

b. Safety Precautions when using a Storage Battery

- 1) Do not overfill the battery when servicing.
- 2) Use water and baking soda to clean the top of the battery to neutralize acid.
- 3) Always use a battery lifter to remove and transport batteries.
- 4) Immediately wash clothing and any part of the body that comes in contact with the acid.
- 5) Wear goggles when using a battery charger.
- 6) Turn off charger before disconnecting leads from the charger to the battery.

ACTIVITY:

1. Compare various written and practical safety tests for the safe operation of shop machinery. Determine which ones are most valid and useful and why. Explain.
2. Build a project that utilizes as many of the woodworking tools as there are available in the shops. Simple projects such as cutting boards will utilize many of the pieces of equipment.
3. Build a project utilizing as many metalworking tools as there are in the shop.
4. Obtain and show films and videos that illustrates the importance of safety in the shop. Check to see that the school shop does not have any safety hazards.

References:

Burke, Stanley R., & Wakeman, T. J. (1990). MODERN AGRICULTURAL MECHANICS. (2nd ed.). Danville, IL: Interstate Publishers.

Cooper, Elmer L. (1987). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS. Albany, NY: Delmar Publishers

Special Materials and Equipment:

Safety worksheets, tools listed in the lesson, shop diagrams of tool placement.

Name _____

Date _____

Score _____

TOOL USE AND SHOP SAFETY, EXAM

1. When should safety glasses be worn?
 - a. while grinding
 - b. while using the whetstone
 - c. when hammering
 - d. all of the above

2. The best way to remove metal cuttings or chips from your work is to use:
 - a. Your hand
 - b. Blow it away with a deep breath
 - c. A brush
 - d. A tool

3. To stop a metal lathe from rotating, you should:
 - a. use your cutting tool
 - b. blow it away with a deep breath
 - c. turn the power off
 - d. remove the tool post

4. When you turn off the switch on the portable electric drill, you should:
 - a. disconnect the electrical cord
 - b. inspect the rotor
 - c. blow the saw dust out of the armature openings
 - d. hold the machine firmly until it comes to a dead stop

5. Drill press work should be held:
 - a. with a pair of tongs
 - b. by the hands
 - c. in a vise or firmly clamped to the table
 - d. by an assistant at all times

6. You should always draw the curtains on the welding booth before you strike an arc to:
 - a. protect your eyes from the infrared and ultra violet rays
 - b. keep the work from getting cool
 - c. prevent anyone from noticing mistakes
 - d. protect anyone nearby from the infrared and ultraviolet rays

7. Before leaving heated metal unattended, you should use chalk or soapstone to label it with the word "hot" because:
- someone may be burned if it is touched
 - other work may be placed on it
 - you can tell to whom it belongs
 - other students will be afraid to steal it
8. A good neutralizer for cleaning off the top of a storage battery is water and:
- ammonia
 - baking soda
 - lye
 - lime
9. When cutting short woodstock on a band saw, the wood should be fed with:
- the left hand only
 - the right hand only
 - both hands
 - a pushstick
10. The portable electric saw is a combination of which two tools:
- circular saw and a power hand saw
 - back saw and hack saw
 - bow saw and electric drill
 - hand saw and power saw
11. The radial-arm saw is used to:
- cut circles
 - cut long pieces of wood down to a usable size
 - cut intricate designs
 - cut pipe
12. You should install the scroll saw blade to cut:
- on the down stroke of the saw
 - at minimum speed
 - on the upstroke of the saw
 - on both the up and the downstroke of the saw

13. You should feed stock into the scroll saw:
- a. in rhythm with motion of the hold down
 - b. as fast as the blade will cut without bending the blade
 - c. from behind the cutting blade
 - d. at a rate dependent upon pulley speed
14. The jointer is used to:
- a. connect the ends of two boards together
 - b. crosscut boards
 - c. rip boards
 - d. smooth a surface of a board
15. Never use stock on a jointer that is shorter than:
- a. 5 inches
 - b. 24 inches
 - c. 10 inches
 - d. 3 inches
16. The shaper can be used to:
- a. cut the design on picture frames
 - b. align boards to be glued and clamped
 - c. smooth rough edges on metal pipe
 - d. secure and rotate a piece of wood while working with hand tools
17. To avoid breathing problems due to sawdust when using a belt sander, the operator should:
- a. continually blow the sawdust away
 - b. angle the sander to shoot the dust away from the operator
 - c. open the window
 - d. wear a respirator
18. The tool rest on a wood turning lathe should be set so it is:
- a. in slight contact with the stock
 - b. below and left of center
 - c. the same distance as the length of the tool handle being used
 - d. one-quarter inch or less from the rough stock

Answer Sheet

1. D
2. C
3. C
4. D
5. C
6. D
7. A
8. B
9. D
10. A
11. B
12. A
13. B
14. D
15. C
16. A
17. D
18. D

Tool Identification: Lay out different tools on the work benches or tables and have students write down the proper names of the tools.

TOOL IDENTIFICATION

Write in the proper names of the tools in the blank spaces provided.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

11. _____

12. _____

13. _____

14. _____

15. _____

16. _____

17. _____

18. _____

19. _____

20. _____

21. _____

22. _____

23. _____

24. _____

25. _____

26. _____

27. _____

28. _____

29. _____

30. _____

31. _____

32. _____

33. _____

34. _____

35. _____

36. _____

37. _____

38. _____

39. _____

40. _____

41. _____

42. _____

43. _____

44. _____

45. _____

46. _____

47. _____

48. _____

49. _____

50. _____

Tools and Equipment

Awl



6 1/4-7 1/8"

Bar, crow



48-66"

Bar, wrecking



12-48"

Bevel, sliding T



8" blade

Bit, auger, solid center



10"

Bit, expansion



10"

Bit, holder, extension



12"

Bit, masonry



6-16"



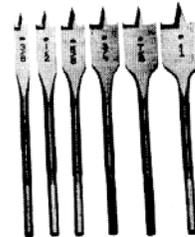
3-6"

Bit, screwdriver



(straight or phillips, torx)
2-3"

Bit, spade



7" long

Blade metal, abrasive cut-off



10-14"

Brace, carpenter's



(10" sweep)

Brush, paint



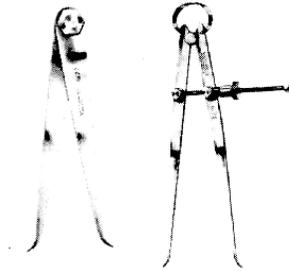
7" long, 1/2-6" wide

Brush, steel wire



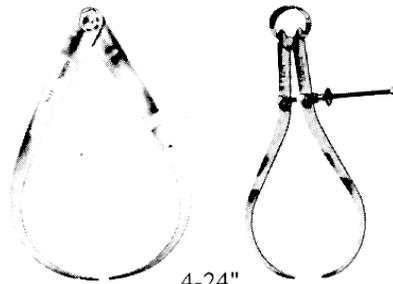
6-14"

Calipers, inside



4-12"

Calipers, outside



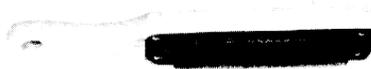
4-24"

Calipers, vernier



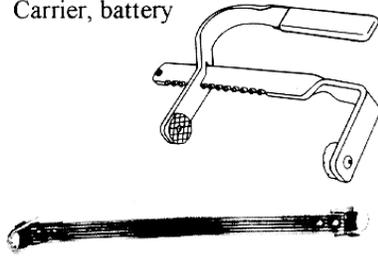
9-18" long

card, file



8"

Carrier, battery



12-24"

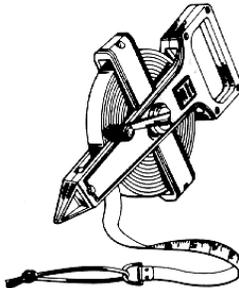
Chain, chainsaw, chipper



Chain, chainsaw, chisel



Chain or tape, surveyors

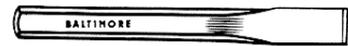


Chisel, cape



5-7"

Chisel, cold



5-8 1/2"

Chisel, diamondpoint



5-8"

Chisel, roundnose



5-8"

Chisel, wood



7-9" long
1/4-2" wide

Clamp, "C"



Regular Throat

Round Frame



Medium Throat



Deep Throat

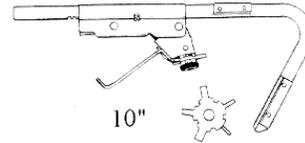
2-16"

Clamp, fixtures, I bar



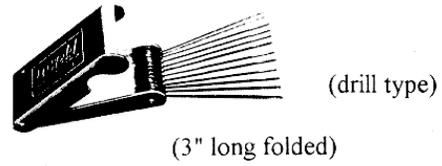
2-8'

Cleaner, ring groove



10"

Cleaner, oxy-acet tip



(drill type)

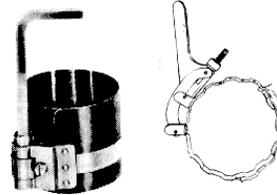
(3" long folded)

Clamp, fixtures, pipe



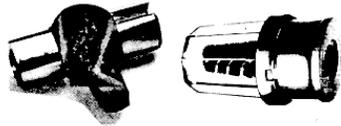
2-8'

Compressor, piston ring



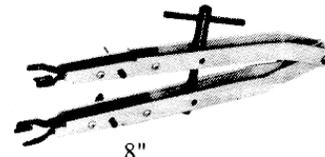
2-6" diameter

Cleaner, battery post

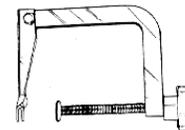


3"

Compressor, valve spring

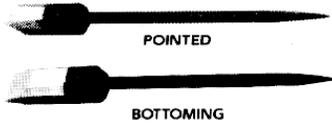


8"



6-20"

Copper, Soldering



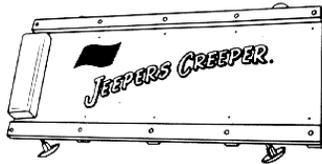
14"

Countersink



2-4"

Creeper, Auto



36"x27"

Cutter, bolt



14-42"

Cutter, glass



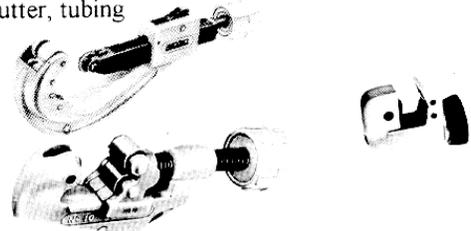
6"

Cutter, pipe



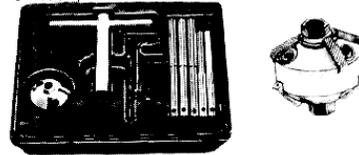
18"

Cutter, tubing



2 1/2-8"

Cutter, valve seat



Box
9"x12"

Die stock



10-24"

Die, thread cutting



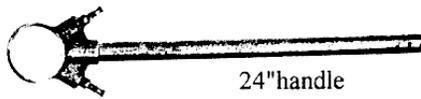
1-3" diameter

Die, pipe threading



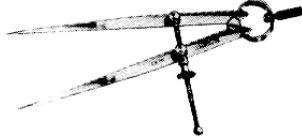
2-4" diameter

Die, pipe threading handle



24" handle

Divider, spring



6-24"

Divider, wing

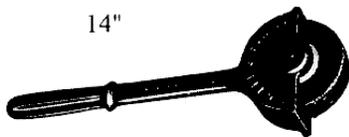


6-24"

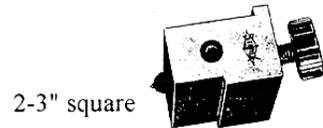
Dresser, Emery wheel



14"

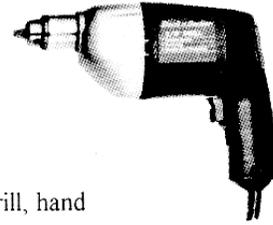


14"



2-3" square

Drill, electric



Drill, hand



12"

Drill, star



8-14"

Drill, twist, straight



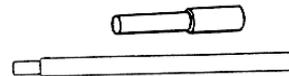
2-7"

Drill, twist, taper shank



8-24" long

Driver, bushing



1/4-2" diameter, 4-10" long

Driver, nut



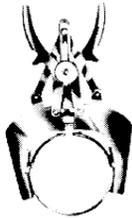
6"

Edger, concrete



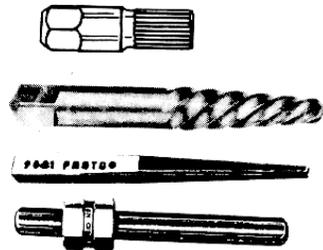
4"

Expander, piston ring



6"

Extractor, screw



2-5"

Extractor, tap



3"

File, chainsaw



6-12"



File, doublecut, flat



6-14"

File, mill



6-14"

File, round



6-14"

File, slim taper



6-14"

File, square



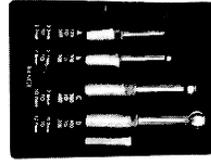
6-14"

Flaring tool, copper tubing



6 1/2"

Gauge, small hole

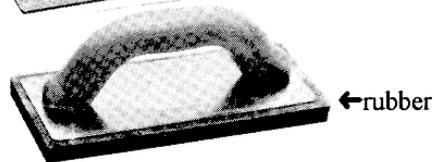


4"

Float, concrete



←magnesium



←rubber



←wood

8-24" long

Gauge, tap and drill

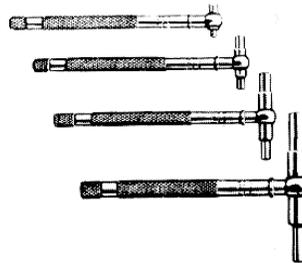


2x5"

Gauge, depth

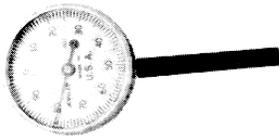


6"



4"

Gauge, dial indicator



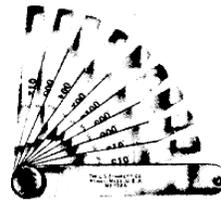
1 1/2" diameter

Gauge, thickness

Gauge, screw pitch

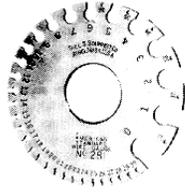


(3" long folded)



(leaves 1/2 x 3")

Gauge, wire (American Standard)



3" diameter

Gauge, wood marking



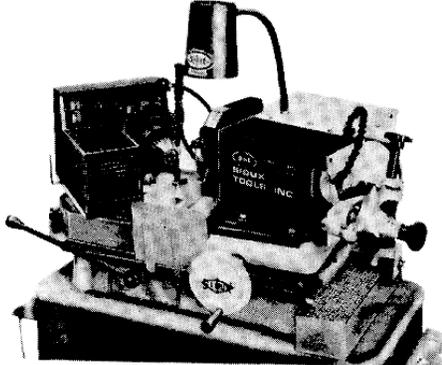
8"

Grinder, electric disc



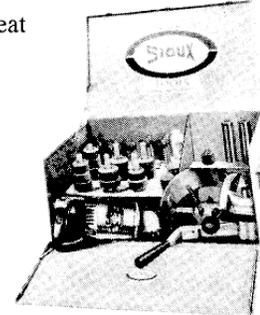
4-10" diameter disc

Grinder, valve



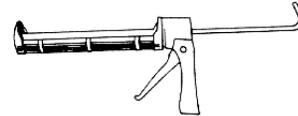
36" wide

Grinder, valve seat



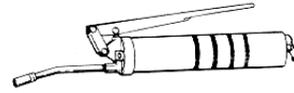
(Box- 24" wide)

Gun, caulking



(15" plunger in)

Gun, grease



18"

Gun, soldering



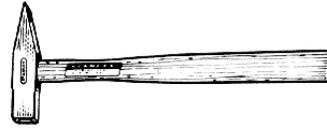
12"

Hammer, ball pein



8-15"

Hammer, Tinner's riveting



14"

Hammer, bell faced, curved claw



13-18"

Handle, axe



BENT SINGLE BIT AXE

Lengths: 30" to 36" — For 3 to 5 lb. Axes



DOUBLE BIT AXE

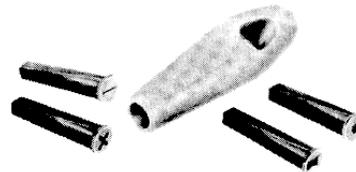
Lengths: 30" to 36" — For 3 to 5 lb. Axes

Hammer, bell faced, straight claw



13-18"

Handle, file



all 4" long

Hammer, Blacksmith's cross pein



15-18"

Hammer, chipping or slag



14"

Handle, hand saw



Hatchet, broad



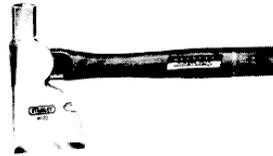
18"

Handle, Machinist's hammer



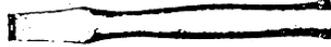
MACHINIST'S BALL PEIN HAMMER
Lengths: 10" to 24" — For 2 oz. to 48 oz. Hammers

Hatchet, half



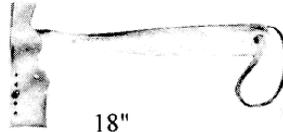
18"

Handle, nail hammer



NAIL OR CLAW HAMMER
Lengths: 12" to 16" — 10"

Hatchet, shingling



18"

Handle, plane



4"

Holder, flywheel



18"

Handle speeder



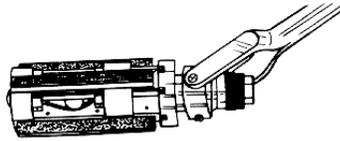
12-24"

Hone, brake cylinder



12"

Hone, cylinder



4" long stones

Indicator, speed



6"

Iron, soldering, electric

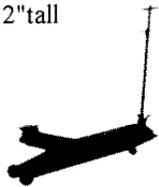


14"

Jack, hydraulic



6-12" tall



26-60" long

Jack, screw

12-24" tall

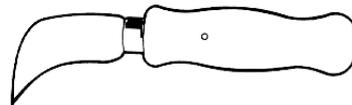


Knife, draw



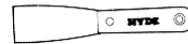
15"

Knife, linoleum



7"

Knife, putty



7"

Knife, utility



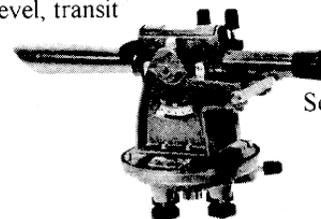
6"

Level, carpenter's



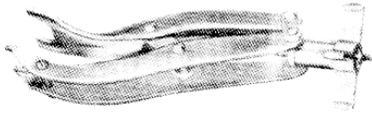
18-48"

Level, transit



Scope 12-18"

Lifter, valve



8"

Line, chalk



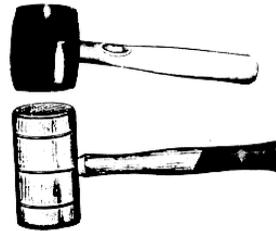
5"

Light, timing



10"

Mallet, rubber or wood

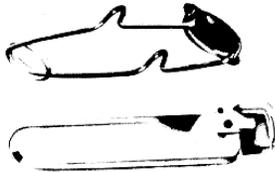


15"

Light, trouble



Lighter, spark



8"

Micrometer, outside



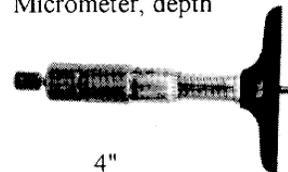
3-12"

Micrometer, inside



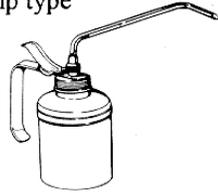
2-7"

Micrometer, depth



4"

Oil can, pump type



Oil can, spring bottom

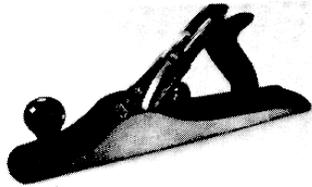


Plane, block



6"

Plane, jack



14"

Plane, jointer



24"

Plane, smooth



10"

Pliers, battery or gripping



6"

Pliers, tongue and groove



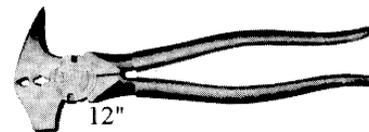
4-24"

Pliers, diagonal cutting



6-8"

Pliers, fencing



12"

Pliers, hose clamp



7"

Pliers, Lineman's



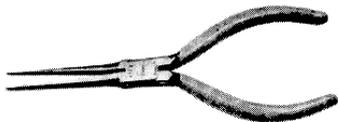
6-8"

Pliers, locking



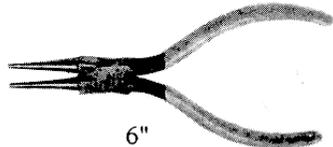
4-12"

Pliers, needlenose



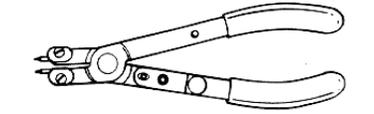
6"

Pliers, roundnose



6"

Pliers, snap ring



6-8"



8"



5"

Pliers, universal slip joint



6"

Plumb bob

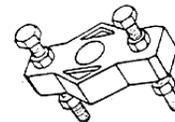


3"

Puller, flywheel

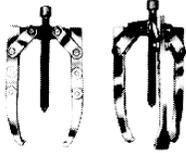


2" (puller, knocker)



3"

Puller, gear



3-12" Jaws

Puller, nail

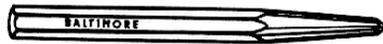


10"



16"

Punch, center



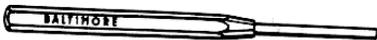
6"

Punch, long taper (Aligning)



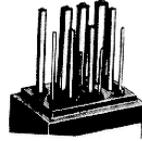
6-12"

Punch, pin

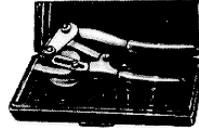


6'10"
1/16-3/8" small end diameter

Punch, roll pin or pilot



Punch, sheet metal



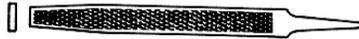
10"

Punch, starter



6"

Rasp, wood, flat



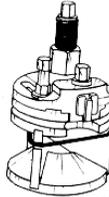
8-12"

Rasp, wood, half round



8-12"

Reamer, cylinder ridge



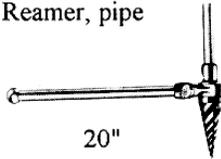
3" diameter
5" tall

Reamer, expansion



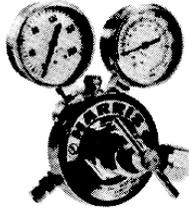
5-20"

Reamer, pipe



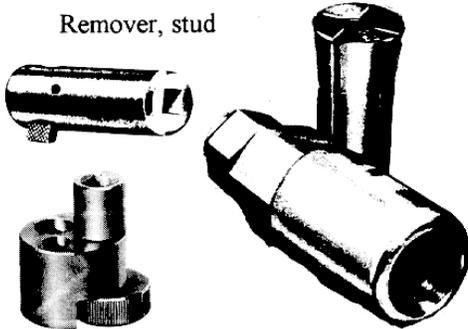
20"

Regulator, Acetylene or Oxygen



Acetylene-left hand male thread inlet-max press 400
Oxygen-right hand female thread inlet-max press 3000

Remover, stud



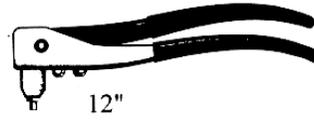
2-3" long

Ripper, cable



3"

Riveter, pop



12"

Rule, Machinist's



6-36"

Saw, back



12-14" blade

Saw, circular, combination



6-12" diameter

Saw, circular, plywood



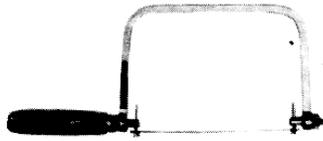
6-12" diameter

Saw, compass



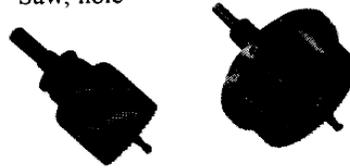
12-14" long blade, 8 teeth/inch

Saw, coping



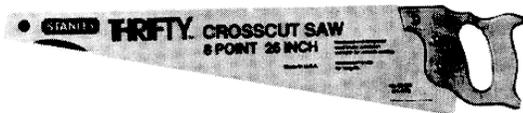
6" blade

Saw, hole



1/2-6" diameter

Saw, hand crosscut



26-30" blade

Saw, keyhole



10" blade, 10 teeth/inch



(Courtesy E. C. Atkins and Co.)

5.12. Views showing a properly filed and set crosscut hand saw. Note the bevel on the front of the teeth.

Saw, meat



12-24" blade

Saw, hand hack



10-14" blade

Saw, pruning



18"



18-24"

Saw, hand rip



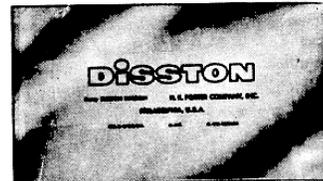
26-30" blade



(Courtesy E. C. Atkins and Co.)

5.13. Views of a section of a rip saw which has been correctly filed and set. Note there is no bevel on the front of the teeth. The teeth are filed straight across.

Scraper, cabinet



3-6"

Scraper, carbon



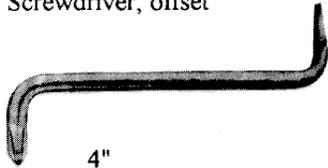
7"

Screwdriver, common



4-18"

Screwdriver, offset



4"



4"

Screwdriver, Phillips



4-18"

Screwdriver, stubby



3"

Screwdriver, torx



6-12"



Scriber



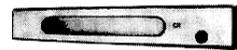
6"

Set, nail



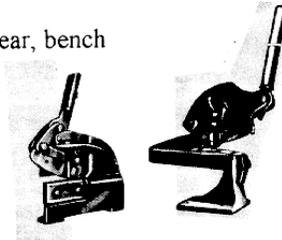
4-6"

Set, rivet



6"

Shear, bench



Shear, pruning

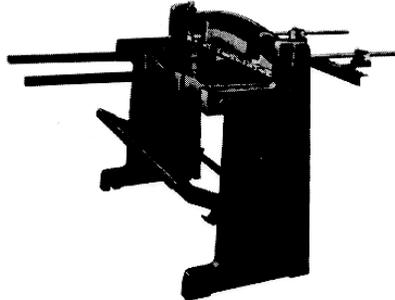


24"



9"

Shear, squaring



3' high, 3-5' wide

Shield, face



Sink, heat



6"

Sledge, Blacksmith, double face



40"

Snips, Tinner's Aviation



9"

Snips, Tinner's, combination



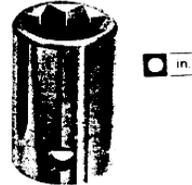
8-14"

Socket, 6 point



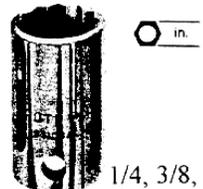
1/4, 3/8, 1/2" drive

Socket, 8 point



1/4, 3/8, 1/2" drive

Socket, 12 point



1/4, 3/8, 1/2" drive

Socket, deep



1/4, 3/8, 1/2"

6 pt. or 12 pt. regular or impact

Socket, impact



6 pt -3/8, 1/2" drive
regular or deep

Socket, reducer



1/2" to 3/8"
3/8" to 1/4"

Socket, universal



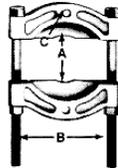
1/4, 3/8, 1/2" drive

Splitter, nut



5"

Splitter or Separator, bearing



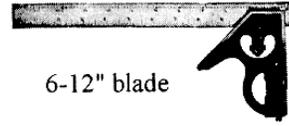
3-9" at B

Spoon, brake adjusting



9"

Square, combination



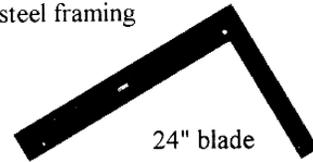
6-12" blade

Square, protractor head



12" blade

Square, steel framing



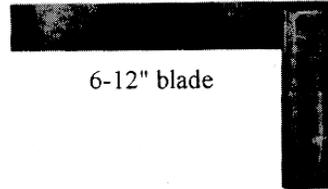
24" blade

Square, T



18-36"

Square, Try



6-12" blade

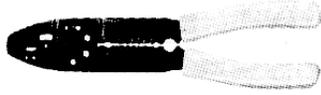
Stone, bench, sharpening



3-8"

(white, gray, black, brown)

Stripper and Crimper, wire



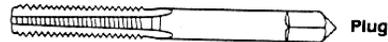
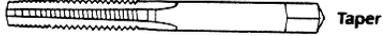
9"

Tachometer, vibration



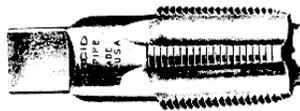
3" diameter

Tap, Machinist's hand



0-80- 3/4" x 4" long

Tap, pipe



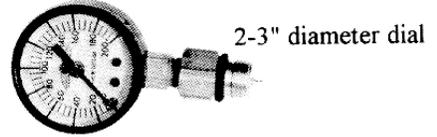
pipe sizes 1/8 -1" x3" long

Tape, flexible steel



6' -300' tape length

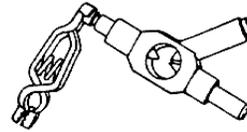
Tester, compression



Tester, spark

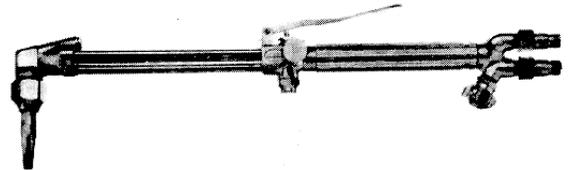


12"



3"

Torch, cutting



15-30"

Torch, propane



16" tall with tank

Torch, welding



8-18"

Trowel, masonry, brick



10-12" blade

Trowel, masonry, pointing



4 1/2-6" blade

Trowel, concrete



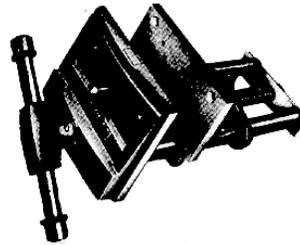
4"x12,14,16"

Trowel, plasterer's



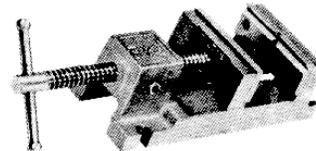
4 1/2-5" x 11, 12, 14"

Vise, carpenters



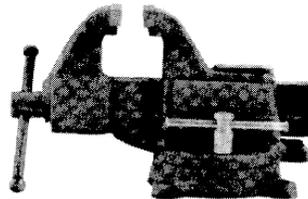
handle 10-12"

Vise, drill press



6-20"

Vise, Machinist's



(2-8" wide jaws)

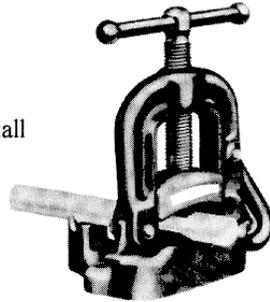
Vise, pipe, chain type



12" wide

Vise, pipe, hinged type

9" tall



Wedge, falling



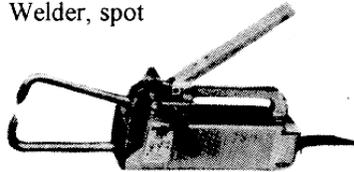
7-11" (plastic or aluminum)

Wedge, splitting



7-11" (steel)

Welder, spot



24-30" overall length

Welder, plastic



A complete plastics welding outfit for production and general shop use, or vocational trade school. Kit contains 51-1188 Unit items plus one tacking tip and handy plastic carrying case with complete instructions and VCR tape.

Wheel, emery grinding



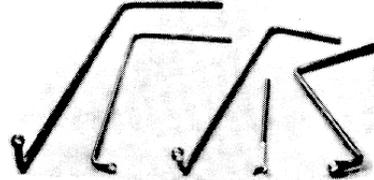
2-16" diameter

Wrench, adjustable



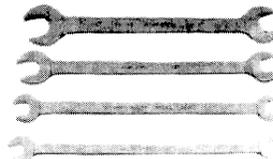
4-24"

Wrench, distributor



8-15"

Wrench, double end, tappet



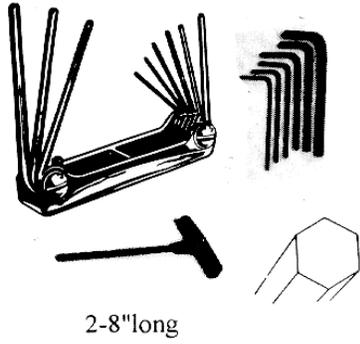
12-15"

Wrench, double offset, box pattern



5-14" long

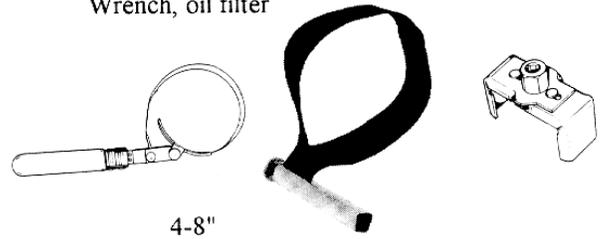
Wrench, hex



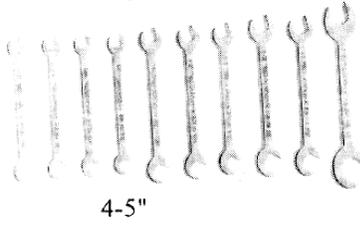
Wrench, internal pipe



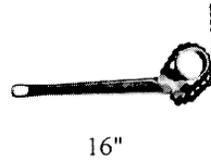
Wrench, oil filter



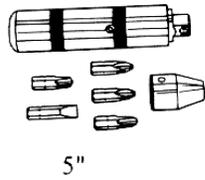
Wrench, ignition



Wrench, pipe, chain



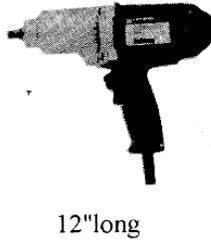
Wrench, impact, hand



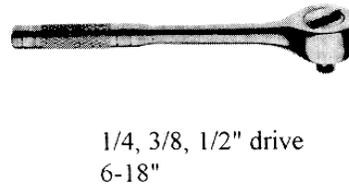
Wrench, pipe, stillson type



Wrench, impact, electric or air



Wrench, ratchet

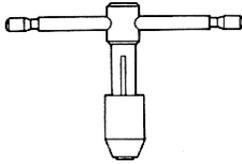


Wrench, starter clutch



3" diameter
3" tall

Wrench, tap, T-handle



3-6" handle

Wrench, torque



in-lb. or ft.-lb.
10-24"
1/4, 3/8, 1/2" drive

Hardware Identification

Anchors, concrete

SELF DRILLING ANCHOR FLUSH END DOUBLE EXPANSION ANCHOR



THREAD SIZES
1/4" THRU 3/4"

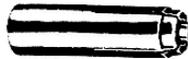


THREAD SIZES
1/4" THRU 1"

MACHINE SCREW ANCHOR STEEL ANCHOR INTERNAL PLUG



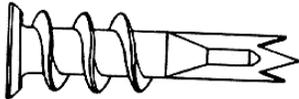
THREAD SIZES
6-32 THRU 3/4-10



THREAD SIZES
1/4" THRU 3/4"

1 1/2-2 1/2 "

Anchor, sheetrock



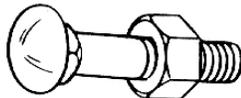
2" (metal)

Block, Snatch



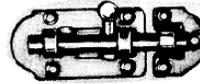
2-8" diameter pulley

Bolt, carriage



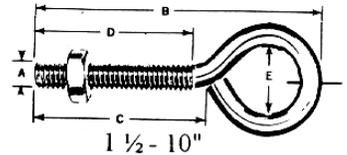
1/4 - 1/2" diameter
1-10"

Bolt, door, barrel type



3-4"

Bolt, eye



Bolt, foundation



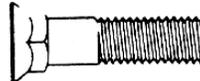
8-12"

Bolt, machine (cap screw)



1/4 x 1/2 " to 3/4 x 10" N.C. or N. F.

Bolt, plow



Diameters 3/8" thru 1-1/4"
Lengths 1" thru 8-1/2"

Bolt, shoulder



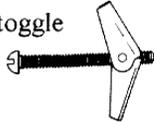
1/4 x 2" to 1/2 x 4"

Bolt, stud



1/4 x 2" to 3/4 x 4"

Bolt, toggle



1/8 x 2" to 1/4 x 6"

Bolt, U



3/16 to 1/2 " diameter bolt

Box, electrical, outlet or junction



4x4" x 1 1/2 to 2 1/2 deep

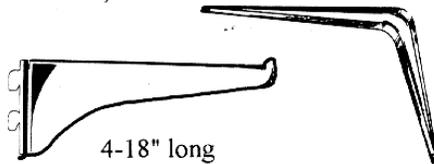
(metal or plastic)

Box, electrical, receptacle or switch



2x4" x 1 1/2 to 2 1/2 deep

Bracket, shelf



4-18" long

Brad, wire

15-20 gauge, 1/2 - 1 1/2 " long



Bushing



Plastic or metal

1/2 -2" diameter, 1/4 -3" long

Cable, "Romex" non-metallic



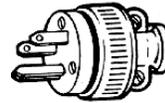
14-10 gauge (has paper filler)

Cable, " Romex", underground feeder

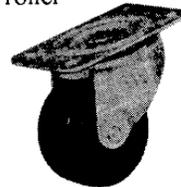


14-10 gauge (no paper filler)

Cap, electric cord , plug



Caster, roller



1-8" diameter wheel

Caulking



10" long roll

Chain, roller



1/4 " -1" wide

1/2 - 1 1/2 long links

Clamps, hose



1/4 -4" diameter

Clip, wire rope



for 1/4 -1" cable

Clevis, common



1-6"

Cloth, emery

8 1/2 x 11 sheets
1-2" strips
Abrasive with cloth backing

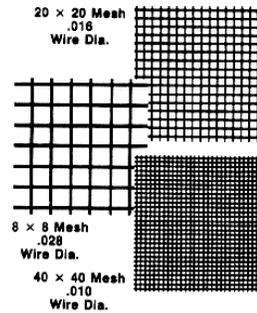
Clevis, screw pin



1-6"

Cloth, wire

Galvanized, stainless steel, brass,
copper, plain steel, aluminum
20x20 means 20 openings per inch each way



Clip, Alligator



1-2"

Conduit, thin walled



1/2- 2" diameter

Clip, hairpin



1-3"

Connector, electrical cord



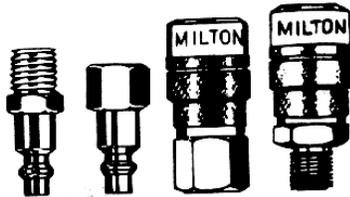
Connectors, solderless



- Heavy ribs for easy grip
- Standard colors for easy identification
- Approved for copper and/or aluminum wire
- UL listed

Stock No	Wire Comb. Range	Color	Box/100
22-6600	72B=3 #16	Black	55.10
22-6602	73B=3 #16 & 1 #18	Orange	6.50
22-6604	74B=2 #14 & 3 #16	Yellow	6.90
22-6606	76B=2 #10 & 1 #12	Red	9.50

Coupler, air and nipple



1 1/2" - 2 1/2"

Fastener, corrugated



1/2-1" long

Fiberglass, corrugated



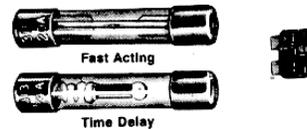
comes in 2' wide sheets

Fittings, grease



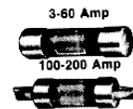
1/2 - 1"

Fuse, automotive



1/2 - 1 1/2"

Fuse, cartridge



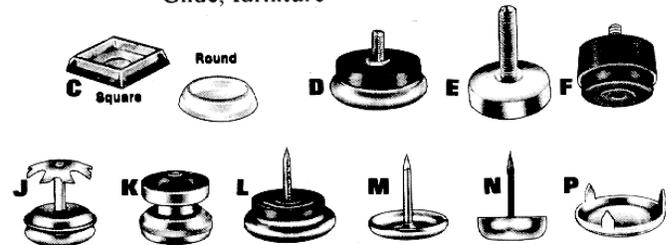
1-4"

Fuse, plug

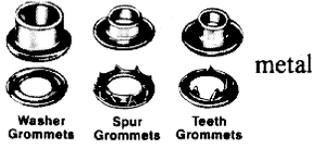


Fuse
1" diameter

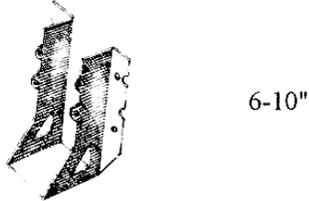
Glide, furniture



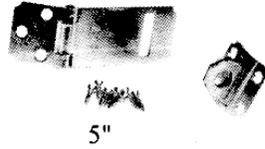
Grommet



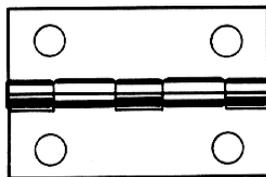
Hanger, joist



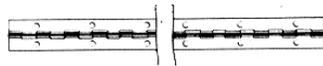
Hasp, safety



Hinge, butt



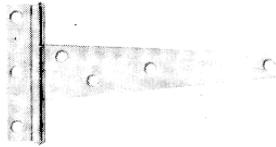
Hinge, continuous



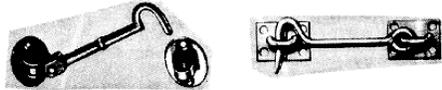
Hinge, strap



Hinge, T



Hook, gate



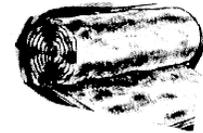
Insert, threaded



Insulation, batt type



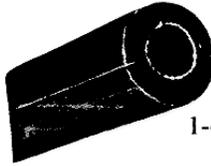
Insulation, foil type



Insulation, granulated type



Insulation, pipe



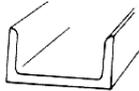
1-4" diameter

Iron, angle



3/4 - 6" legs

Iron, channel

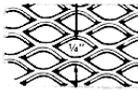


3/4 - 6" wide

Iron, deck plate



Iron, expanded metal



Iron, galvanized

Any shape iron coated with zinc

Iron, I-bar



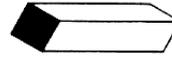
2-8" tall

Iron, round



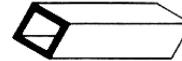
1/4 to 2" diameter

Iron, square



1/2 - 2" square

Iron, square tubing



1/2 to 6" square

Key, woodruff



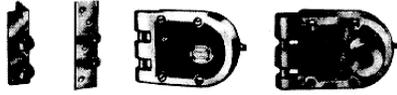
1/4 - 1 1/2" long

Key, stock

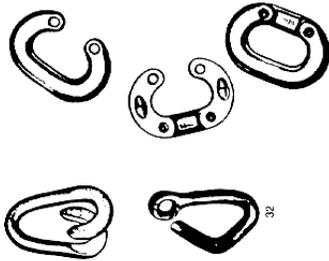


1/16 - 1/2 x 12" long

Latch, door



Link, chain repair



1-3"

Lock, door



4" long

Lock, drawer



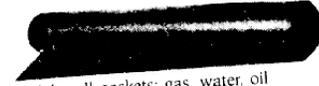
2"x3"

Lock, pad



1/2-3"

Material, gasket



• Ideal for all gaskets: gas, water, oil

black, cork, gray, green,
varying thicknesses, 1/32 - 1/8"

Metal, sheet, corrugated, aluminum



2' or 3' width x any length

Metal, sheet, corrugated, galvanized

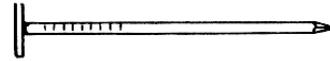


2' or 3' width x any length

Nail, box

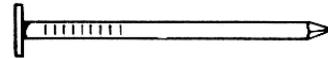


Nail, cement coated

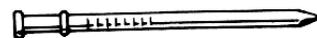


(coated with brown glue)

Nail, common



Nail, duplex (double headed)



Nail, finish



Nail, galvanized box



(coated with zinc)

Nail, joist hanger



(actual size)

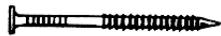
Nail, roofing, neoprene washer



Nail, masonry



Nail, ring shank



Nail, roofing, large head

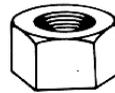


1-2"

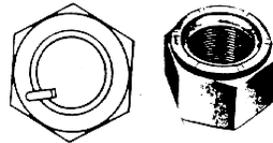
Nut, castellated



Nut, machine N.F.



Nut, self locking



Nut, standard N. C.



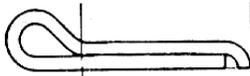
Nut, thumb (wing)



Paper, emery
8x11 sheets
Abrasive - black,
paper backing

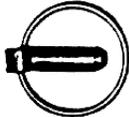
Paper, sand
8x11 sheets
Light brown abrasive

Pin, common cotter



1/2 - 3"

Pin, lynch



2-3" diameter

Pin, roll or tension



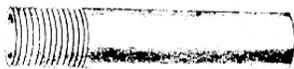
1/16 - 1/2" diameter

Pipe, black iron



1/8-2" diameter

Pipe, galvanized iron



1/8-2" diameter

Pipe, iron fittings

Elbow, 90°



Elbow, 45°



Elbow, street, 90°



Tee



Cap



Union



Union, dielectric

For connections between dissimilar metals. Designed for air and water service. Maximum pressure: 250 psi. Maximum temperature: 210° F.



Plug



Sq. Head Plug

Bushing



Coupling



Nipple

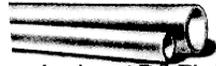


Pipe, plastic, ABS DWV - black



1 1/2 - 4" diameter

Pipe, plastic, PVC - White



1/2 - 4" diameter

Pipe, plastics, ABS Fittings - black

Pipe, plastic, PVC fittings - white



SP x Hub
**90° 1/4 Bend
Street Elbow**



SP x Hub
45° Street Elbow



FPT x Hub
Female Adapter



MPT x Hub
Male Adapter



MPT
Plug



Hub x Hub
**90° Elbow
1/4 BEND**



Hub
Closet Flange



Hub x Hub
Coupling



90°
Elbow



45°
Elbow



Tee



Coupling



Female
Adapter



Male
Adapter



Cap



Union

Pipe, copper, flexible



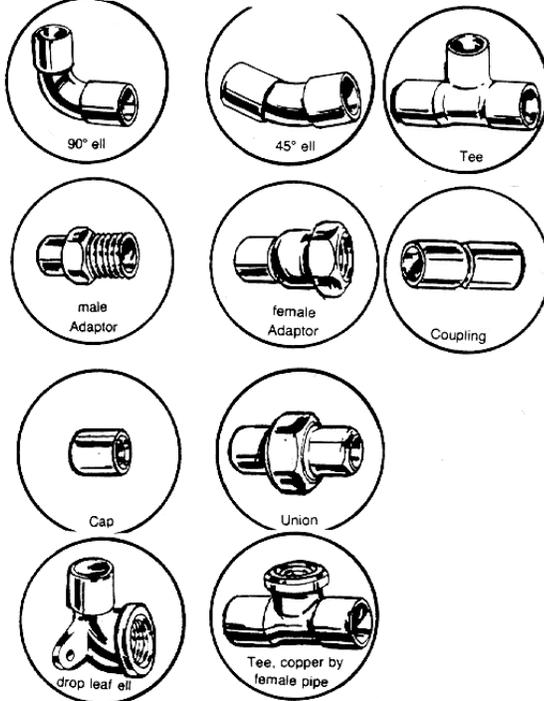
1/4 - 1/2" diameter
comes in 50' roll

Pipe, copper rigid



1/2 - 3" diameter
10' or 20' lengths

Pipe, copper rigid fittings

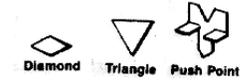


Plate, strike



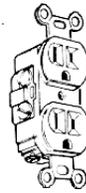
2 1/2"

Point, glazier



1/4 - 1/2"

Receptacle, duplex



Ring, retaining, E- clip



Ring, Snap, external



Ring, snap, internal



Rivet, blind or pop

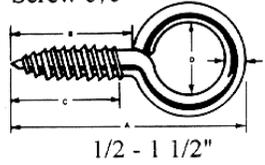


Rivet, copper and burr



1/2 - 1 1/2"
use # 7 x 1/2 for point plunger plug

Screw eye



Rivet, counter sunk head, soft iron



3/4 - 1 1/2"

Screw, lag



1/4 - 1/2" diameter
1" - 8" long

Rivet, flat head, soft iron



1/2 to 2"

Screw, machine flat head

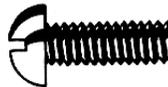


0-80 to 12-24

Rivet, round head, soft iron

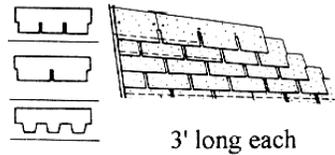


Screw, machine round head

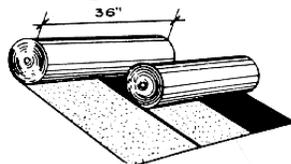


0-80 to 12-24

Roofing, composition shingles



Roofing, roll



Screw, dry wall

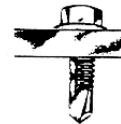


Screw, molly



1 1/2-2" long

Screw, self drilling

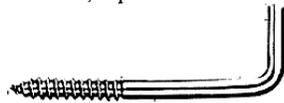


Screw, sheet metal



1/4 - 1"

Screw, square hook



1-3"

Screw, thumb



1-2"

Screw, wood, flat head



1/4 - 4"

black, bright, bronze

Screw, wood, round head



1/4 - 4"

black, bright, bronze

Sealer, sill



6" wide roll
1/4 - 1" thick
could be blue or
yellow foam or
fiberglass

Sheetrock (gypsum)



comes in 4'x8', 10 or 12'
1/4" - 5/8" thick
gypsum rock covered by paper on outside

Shield, expansion



Available in: SHORT and LONG
DIAMETERS AVAILABLE
1/4" THRU 3/4"

Shimstock



.001 - .015 thick
brass, steel, aluminum

Slide, drawer



18-24"

Soapstone



Flat Square Round

4" x 1/8 - 1/4"

Solder bar



Bar solder is available in 1 lb. bars. Uniform distribution of tin-lead alloys provides more efficient and easy application.

Solder, flux core



1 pound rolls

hollow in solder contains flux
1/16 - 1/8 diameter solder

Solder, solid core



1 pound rolls
1/16 - 1/8 diameter solder

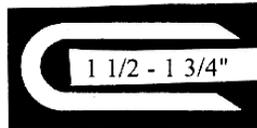
Spring, compression coil



Spring, extension coil



Staple, fence



Staple, poultry netting



3/4"

Staple, Romex



1" long points

Steel, tool

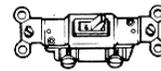


Octagonal



Hexagonal

Switch, single pole



has 2 terminal screws

Switch, 3 way



has 3 terminal screws

Tack, Carpet



1/4 - 1/2"

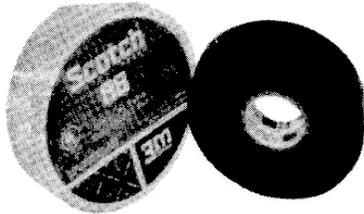
Tack, double pointed



No. 9 No. 10 No. 11 No. 12 No. 14

5/16 - 1 1/16"

Tape, electrical, plastic



black 3" diameter new

Tape, Duct



gray 6" diameter new
2" wide

Tape, Masking

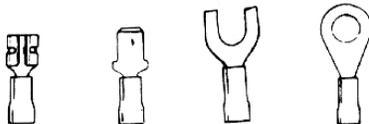


tan, 5" diameter
1/2 - 1" wide

Tape, teflon, plumbing



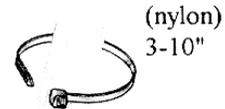
Terminals, wire



Thimble, wire rope



Tie, cable



(nylon)
3-10"

Tubing, heat shrink



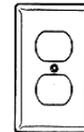
- Shrinks to half original size when heated
- Insulate terminals, connectors, tool handles and wire splices
- 6" lengths, black, assorted diameters, 23 total pieces

Turnbuckle



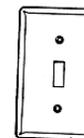
3/16 to 1/2" diameter bolt
3-10" long

Wall Plate, receptacle, duplex



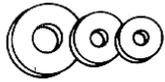
2 1/2 x 4 1/2"
white, brown, metal

Wall Plate, Switch



2 1/2" x 4 1/2"
white, brown, metal

Washer, flat



iron, fiber, brass
aluminum, nylon, felt
1/4-2" diameter

Washer lock



1/16 -2" diameter

Wire, baling

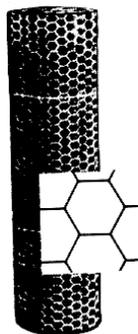


single strand

Wire, barbed



Wire, Poultry netting



mesh 1 1/2"
roll 6' tall

130F-1

SHARPENING HAND TOOLS, RECONDITIONING, AND GRINDER SAFETY

AG 130-F

UNIT OBJECTIVE

After completion of this unit, students will be able to sharpen tools and know how to use bench grinders safely. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Sharpen selected cutting tools correctly, including chisels, screwdrivers, twist drills, blades, hoes, axes, knives, scissors, and shears.
2. Proper use, set-up, and selection of grinding wheels for bench grinders.
3. Proper use of draw file and file card

SHARPENING HAND TOOLS AND GRINDER SAFETY

A. Hand Sharpening Tools Safety

1. Files, rasps, and whetstones are used to sharpen a variety of shop tools. (Much of this information has been presented in previous units, but a review can be of great importance due to the danger of the equipment in use.)
2. Unskilled and/or careless use of files and rasps causes numerous injuries while sharpening tools.
 - a. Never use a file or a rasp without a handle. The pointed end can puncture or lacerate the skin.
 - b. Always use two hands while filing. This prevents the tool from bouncing off the work material and onto the worker. The flat edges of the file or rasp are sharp enough to cut skin.
 - c. Use the file in one direction only. File away from the body to prevent injury. The teeth of the file are generally facing one direction. To file against the teeth will cause the file to bounce off the work material and injure the worker.
3. Whetstones are used to sharpen knives, scissors, and other flat-bladed tools.
 - a. Always keep hands and fingers clear of the area of the stone where the tool is being sharpened.
 - b. Secure the whetstone before sharpening a tool in order to prevent slippage.

B. Grinder Safety

1. A grinder is a piece of power equipment used to abrasively remove metal from a larger piece of material.
2. Two types of grinders are commonly found in the shop.
 - a. A bench grinder is larger in size and must be securely mounted to a table or bench.
 - b. A portable hand grinder can be used anywhere that an electrical source is available.
3. There are many specific safety practices regarding grinders.
 - a. All guards and safety devices must be in place and be operable before using. These devices include shields and eye shields.

- b. The tool rest on the bench grinder must be in proper adjustment at all times.
- c. Inspect the grinding wheel for grooves, cracks, or chips before operating.
- d. Always wear personal eye protection when operating a grinder. Never rely on the eye shields on the grinder alone.
- e. Never wear gloves, neckties, or loose-fitting clothing while operating any power equipment.
- f. Cool the tip of the material being ground often. This prevents a weakening of the metal and possible breaking of the tool.
- g. Never stand directly in front of the grinding wheel as it is coming to speed. A loose-fitting or unbalanced wheel may fly from the assembly and cause serious injury.
- h. Keep the spark deflector in place and never more than 1/8" from the grinding wheel. A space of more than 1/8" allows metal to be pulled between the toolrest and the grinding wheel. This action may catch fingers, cause the metal to be thrown by the grinder, or break the grinding wheel or toolrest.
- i. Always grind on the face of the grinding wheel and never on the sides. Constant side pressure may cause the wheel to break.
- j. Always use two hands when using a portable grinder. The high speeds of the wheel can cause the grinder to fly off the metal and injure the worker.

SAFETY IN TOOL FITTING

A. Safety Practices for Fitting Tools:

Tool fitting is defined as the sharpening, cleaning, redressing, and adjustment of tools so they can better do the work they were designed to do. The following general safety precautions should be observed when fitting tools. As these precautions deal with general tool-fitting applications, other more specific safety measures may need to be implemented when performing specialized tool-fitting jobs.

1. Use solvents and chemicals safely. All solvents and cleaning chemicals used in tool fitting should be handled and stored according to the manufacturers' directions. Use solvents and chemicals only in well-ventilated areas. When using many chemicals, you must wear rubber gloves.
2. Fasten or hold tools to be fitted securely. Hold the workpiece firmly when grinding, filing, or performing other reconditioning operation. Do not allow the workpiece to be thrown, dropped, or chipped while it is being fitted.

130F-4

3. Use handles on files when tool fitting. File handles will prevent the tang from being gouged into the hand.
4. Wear approved eye protection. Industrial-quality eye protection should be worn at all times.
5. Avoid loose-fitting clothing when you are grinding. Do not wear long sleeves and loose-fitting clothing when you are using a grinder because they are cumbersome and could get caught on the grinder.
6. Gloves are recommended only when materials being handled will cause injury to the hands. Gloves are awkward; thus, they produce extra hazard, especially for the worker who is using a grinder.
7. When using the stationary grinder for tool fitting.
 - a) Keep the tool rest no more than 1/8" from the grinding wheel.
 - b) Sound the grinding when it is mounted for cracks and internal flaws.
 - c) When turning on the machine, stand to the side of the grinding wheel. Never stand in direct line with the grinding wheel while it is coming up to operating speed.
 - d) Keep the face of the grinding wheel true. Use a grinding wheel dresser to true the wheel and remove glaze from the wheel surface.
 - e) Keep grinder eye shields in place and clean at all times.
 - f) Keep the spark deflector in place and adjusted so it is never more than 1/8" from the grinding wheel.
 - g) Grind only on the face of the grinding wheel. Heavy side pressure may cause the grinding wheel to break and then strike the operator.
 - h) Replace the grinding wheel when it is worn to within half of its original diameter. The surface grinding speed of the wheel is reduced when the grinding wheel is worn, resulting in a rough grinding surface. It is also difficult on most grinders to keep the toolrest adjusted to within 1/8" of the grinding wheel when the wheel is worn to less than half of its original diameter. If the toolrest cannot be properly adjusted, a safety hazard exists. A space of more than 1/8" allows metal to be pulled between the toolrest and the grinding wheel. This action may catch fingers, cause the metal to be thrown by the grinder, or break the grinding wheel, toolrest, or both.
 - i) Use water to cool the tools being fitted. Frequent cooling prevents loss of temper from the tool and burns to the operator. Tools should be cooled enough to hold in your hand without burning before grinding is resumed.
 - j) Do not grind when other workers are near. A bump to someone grinding may cause serious accident.

- k) Never leave the grinder running unattended.
- l) Do not exceed the recommended speed (RPM) of the grinding wheel.
- m) Never modify a grinding wheel to run on an arbor shaft smaller than the smallest bushing provided with the grinding wheel.

* Reprinted by permission of Interstate Publishers, Inc., from MODERN AGRICULTURAL MECHANICS, 2nd ed., by Stanley R. Burke and T. J. Wakeman. Copyright 1992 by Interstate Publishers, Inc.

GRINDER AND WHEEL SELECTION

A. Introduction

1. A grinder wheel is a wheel made of abrasive grit that is bonded together with a special material to hold the wheel together at high RPMs. Consideration should be given to grinder size, wheel size, and material to be ground when selecting a grinder wheel.
2. Grinder wheels are sized according to a variety of factors:
 - a. Diameter - The diameter of a wheel to be selected is determined by the size of the grinder it is to be used on. Common grinding wheel diameters include 5," 6," 7," 8," 10," and 12" sizes.
 - b. Width - Grinder wheels come in a variety of widths depending on the grinder size and application.
 - c. Grit Number - The grit is determined by the size of the pore space between abrasive particles that make up the wheel. The grit number is determined by the material that is to be ground by the wheel. The smaller the grit number, the coarser or rougher the surface of the wheel. Grit numbers range from the number 8, which is very coarse, all the way up through 240, which is very fine.
 - d. Arbor Hole Size - The arbor hole is the hole in the center of the wheel that allows the wheel to be mounted on the grinder axle, or arbor. This hole size is determined by the diameter of the arbor on the grinder to be used. The wheel must fit properly or it may spin out of round and may shatter when used.
 - e. Bond - The bond is determined by the material used to hold the abrasives together. The types of bonds commonly used are: vitrified (V), silicate (S), resinoid (B), rubber (R), and metal (E). Most wheels are held together with a vitrified bond. Fine-edged tools are sharpened on wheels that are made of silicate bonds. Rubber and resinoid bonds are used in making disk grinding wheels and cut-off disks. Metal bond is used for making diamond grinding wheels because it is the strongest.

B. Grade Markings (see page 130F-xx)

1. Position 1, Kind of abrasive
 - a. Letter “A” indicates aluminum oxide abrasive.
 - b. Letter “C” indicates silicon carbide abrasive.
2. Position 2, Grain size
3. Position 3, Grade
 - a. Using all letters of the alphabet
 - b. “A” being the softest
 - c. “Z” being the hardest
4. Position 4, Structure – the spacing between the grains or density
 - a. Numbers ranging from 1 (very dense) to 15 (open)
 - b. Number 1 produces a fine finish
 - c. Number 15 produces a course finish
5. Position 5, Kind of bond – holding the wheel together
6. Position 6, Manufacturer’s record
 - a. Specific bond combinations
 - b. Types of reinforcement
 - c. Side treatments furnished

C. Dressing the Grinder Wheel

1. The purpose of dressing the grinder wheel is to insure that it rotates true, is free of grooves on the wheel face, and that the spaces between the abrasive particles do not load up with particles of the material being ground.
2. The dressing tool is a device that removes some of the abrasive particles on the face of the wheel to expose the fresh abrasives below. It is also used to remove grooves and foreign particles from the abrasive surface.
3. Squaring the wheel is important to insure that the wheel spins true. The face of the wheel must be square to the sides after dressing the wheel. This is checked with a square.
4. Truing the wheel is done while the wheel is being dressed so that the wheel is balanced and does not vibrate excessively. If the wheel is not trued, the high speed at which it turns may break the wheel apart.

ACTIVITY:

1. Set up grinders with safety problems and have students inspect them.
2. Identify all of the safety features on grinders and describe the function of each.
3. Set up graphic demonstrations in order to show the effects of improper safety practices. For example, show the effects of a glove or a piece of loose clothing getting caught in an improperly adjusted tool rest.
4. Have students demonstrate the safe use of hand sharpening tools and grinders while sharpening tools.
5. Form a small groove in the face of the grinder wheel to show the students what true is, and then, using a wheel dresser, demonstrate how to properly dress the wheel including removing the groove, squaring the wheel, and checking for true.
6. Give examples of different tools that need to be sharpened and have the students select the appropriate grinder wheel for the job.

TOOL SHARPENING PROCEDURES

A. Tool fitting is defined as the sharpening, cleaning, redressing, and adjustment of tools so they can better do the work they were designed to do.

B. There are several important reasons to fit tools:

1. Workers are able to produce more work safely and with less effort when tools of the trade are well-fitted. A dull axe will not cut into wood as well as a sharp axe, so extra labor is required to do the same amount of work. Since a dull axe does not catch the wood as well, it is more likely to bounce off the wood and injure the worker than a sharp axe. Even a dull axe will break the skin.
2. It is more economical to sharpen a dull tool than to buy a new one.

C. Tool Sharpening Procedures

1. A cold chisel is a hand tool used to cut metal.
 - a. There are several different tip shapes for cold chisels which require a variety of different sharpening techniques. Tip shapes include flat, diamond point, round nose, and cape.
 - b. To sharpen a flat chisel, use a template to correctly grind the beveled side of the chisel. The correct angle ranges from 60 to 75 degrees.
 - c. The cutting edge of the chisel is ground first to remove all chips and gaps. Use the thumb and forefinger to guide the chisel towards the grinder while using the tool rest for support.

- d. After the cutting edge has been cleared of rough edges, turn the chisel over and grind the edge to the appropriate angle. Stop and check the angle of the bevel often to prevent over grinding. Over grinding will decrease the strength of the chisel cutting edge.
 - e. Cool the chisel with water often while grinding to prevent overheating and a loss of temper.
 - f. Check the manufacturer's recommendations for the correct angle to use on a diamond point chisel. Round nose and cape pointed chisels require equal grinding on all sides.
2. Wood chisels are hollow ground to obtain a razor sharp tip.
- a. Wood chisels are sharpened on one side only to an angle of 25° - 30° . The angle can be determined with the use of a template or protractor head square.
 - b. The first step is to grind the cutting edge to make it square and to remove all nicks.
 - c. Grind the edge of the tool, while checking frequently for the correct angle.
 - d. Put a fine edge on the chisel with the use of a whetstone.
3. Screwdriver tips often get worn or bent out of shape and must be fitted.
- a. Select a flat-head screw with a slot the same width as the screwdriver blade tip.
 - b. Grind the tip square and remove all gaps and twists in the screwdriver blade. Apply light pressure to the blade while moving it back and forth across the grinding wheel.
 - c. Turn the screwdriver frequently to keep both sides parallel.
 - d. If ground correctly, the tip should fit completely into the screw slot with no gaps.
4. A twist drill is used to drill holes in metal or wood.
- a. It is important to know the parts of the cutting tip of the twist drill before sharpening.
 - 1) The two cutting lips of the drill perform the actual cutting.
 - 2) The heel is the outer, rounded edge of the drill bit.
 - 3) The dead center is the edge that separates the two cutting lips. The dead center must be exactly centered on the drill bit after it is sharpened.

- b. The two cutting lips are ground at an angle of 59 degrees to the center line of the drill shank.
 - c. The clearance of the twist drill is the difference between the heel and the edge of the cutting lip. The clearance should be 8 – 12 degrees. Too large a clearance will cause the cutting lips to break off. Too small a clearance will cause the drill to ride on the heel and the drill will not cut.
 - d. The procedure for sharpening a twist drill is as follows:
 - 1) Set the tool rest horizontal to the face of the grinding wheel.
 - 2) Hold the drill shank between the thumb and index finger. Rest the back of the index finger on the tool rest.
 - 3) Be sure that the cutting lip is straight across the face of the wheel at the beginning of each stroke. When the drill comes in contact with the wheel, push the drill shank downward and to the left at a slight angle. At the same time, rotate the drill a half turn so that the other lip is just visible.
 - 4) Repeat this process on the other lip to sharpen the entire twist drill.
 - 5) Check the cutting angle and clearance by using a template.
 - e. A hand jig can be used to sharpen drills when a grinder is not available. It is recommended that beginners practice with a hand jig.
4. Rotary mower blades can be sharpened to increase the effectiveness of a lawn mower or a field mower. Sharp blades do a faster, better looking mowing job and reduce the amount of damage to the plants.
- a. Only one side of the rotary blade is sharpened. Try to maintain the original angle of the cutting edge. If this cannot be determined, sharpen the blade to a 45 degree angle.
 - b. To maintain balance in the mower, the blade must be sharpened equally along its edge. A blade that is not sharpened evenly will rotate out of balance and cause the mower to vibrate. This creates wear on the engine, shaft, and body of the mower.
 - c. It is more desirable to use files rather than power grinders to sharpen blades. It is more difficult to properly position a blade edge on a grinder. Uneven grinding may occur which will cause the blade to rotate out of balance.
 - d. The first step in sharpening blades is to remove all nicks and chips from the cutting edge.
 - e. Clamp the blade into a machinist's vise and restore the edge using a large, flat file.

- f. Check the angle of the cutting edge frequently, using a sharpening template.
5. Shovels, hoes, and spades can be easily sharpened with grinders or files.
- a. Shovels are always sharpened on the inside edge. Check other digging tools for the side on which they were previously sharpened.
 - b. Remove all excess metal, nicks, and chips from the cutting edge.
 - c. File or grind a new cutting edge into the tool. Spades and hoes should be sharpened to their original angle. If this is unknown, sharpen to a 20 to 30 degree angle.
6. Axes have a rounded metal side behind the cutting edge. This convex shape requires a special sharpening technique called convex grinding.
- a. The blade of the axe should face up on the edge of the grinder. Use an up and down motion as the axe blade is drawn across the face of the grinding wheel. Stop the downward motion when sparks first appear to prevent the dubbing off of the axe blade.
 - b. The up and down motion should cover a distance of only 3/4" to 5/8" with each stroke.
 - c. A whetstone can be used to remove the wire edge created by the grinder and to put a fine cutting edge on the axe. Draw the blade across the stone at a 30 degree angle. Repeat this process on both sides of the blade.
7. Knives can be sharpened with either a whetstone or an electric grinder. Since there are often rules regarding the use of knives by students at school, the students should receive permission from the instructor before bringing their own knives to school for this exercise.
- a. Only smooth-edged knives can be sharpened using this procedure. Serrated knives should be sent back to the manufacturer for sharpening.
 - b. Select a fine grit wheel since the knife blade is thin and often fragile.
 - c. Hold the knife with the cutting edge up and slowly move it back and forth across the grinding wheel. Do not apply much pressure to the knife as the blade may be damaged. Cool the blade in water often to prevent the blade from heating up.
 - d. Use an oilstone or a whetstone to put a fine cutting edge on the knife.
 - 1) Hold the knife flat to the stone with the back slightly raised.
 - 2) Draw the knife, edge first, across the stone; then flip the knife over and push it in the opposite direction.

- 3) Sharpening oil should be applied to the stone before sharpening to prevent damage to the stone and blade.
- 4) Properly clean the stone after using by wiping the excess oil from the face.

8. Scissors and shears each have two blades that must be sharpened.

- a. Only one side of the blade is sharpened. The shape of the edge is concave and the edge should have an angle of 80 degrees.
- b. Never sharpen the flat side of the blades. The strength of the metal is on this side.
- c. Grind all nicks and chips from the cutting edge.
- d. Grind to an 80 degree angle.
- e. Put a fine edge on the blade using a whetstone.

ACTIVITY:

1. Bring from home various tools that need to be sharpened. Permission should be obtained for some tools, such as knives.
2. Identify correctly and incorrectly sharpened tools.
3. Practice sharpening each of the tools listed in this lesson.

References:

Burke, Stanley R., & Wakeman, T. J. (1990). MODERN AGRICULTURAL MECHANICS (2nd ed.). Danville, IL: Interstate Publishers.

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Special Materials and Equipment:

Examples of hand and bench grinders, rasps, files, and whetstones should be displayed. Slides, videos, films, and demonstrations concerning safe procedure of hand sharpening tools and grinders will be useful in this lesson.

***** NOTE TO INSTRUCTOR *****

Demonstrations should be valid and visual in order to demonstrate the true danger in the use of this equipment. Manuals, teacher guides, student workbooks and audiovisual materials concerning shop safety can be acquired from: American Association for Vocational Instructional Materials, 745 Gaines School Road, Athens, GA 30605. Telephone 1-800-228-4689.

Name _____

Date _____

Score _____

UNIT EXAM, GRINDERS AND SHARPENING

Multiple Choice, Choose the best answer for the following questions.

1. _____ The lip clearance of a drill is between a _____ angle
 - a. 5° – 8° angle
 - b. 8° – 12° angle
 - c. 12° – 15° angle
 - d. 15° – 20° angle

2. _____ A 60 grit wheel is considered to be:
 - a. fine
 - b. medium
 - c. course
 - d. extra course

3. _____ Which type of grinding technique is used with a wood chisel?
 - a. hollow grinding
 - b. convex grinding
 - c. straight grinding
 - d. reverse grinding

4. _____ The center hole of a grinder wheel is called the:
 - a. axle bore
 - b. center hole
 - c. cylinder guide
 - d. arbor hole

5. _____ Which of the following is not a consideration when selecting a grinder wheel to fit a bench grinder:
 - a. arbor hole
 - b. diameter
 - c. width
 - d. strength

- 6._____ A cold chisel is ground to which angle?
- a. 60° – 75° angle
 - b. 80° – 85° angle
 - c. 80° – 95° angle
 - d. 90° – 95° angle
- 7._____ To put the finishing touches on a wood chisel to make it razor sharp, use a:
- a. grinder
 - b. pumice stone
 - c. whetstone
 - d. file
- 8._____ The most correct device to use to check the angles on a tool is a:
- a. square
 - b. template
 - c. protractor
 - d. square angle
- 9._____ The appearance of blue color on a tool you are sharpening indicates that the tip:
- a. is too hot
 - b. is too cold
 - c. is at the correct angle
 - d. should be ground more
- 10._____ A grinder wheel should be discarded when it reaches _____ of its' original diameter.
- a. $1/3$
 - b. $1/4$
 - c. $1/2$
 - d. $2/3$
- 11._____ A center punch tip is ground to a _____ degree angle.
- a. 45° – 60° angle
 - b. 60° – 65° angle
 - c. 70° – 75° angle
 - d. 80° – 85° angle

- 12.____ The part of the drill bit that does the actual cutting is called the:
- cutting heel
 - cutting edge
 - cutting margin
 - cutting point
- 13.____ Which of the following should NOT be worn while using a grinder:
- safety glasses
 - gloves
 - protective clothing
 - all of the above
- 14.____ A groove in the center of a grinder wheel may be fixed by the use of a:
- wheel dresser
 - grinder
 - file
 - whetstone
- 15.____ Which of the following is a soft metal that would “load” the wheel?
- brass
 - tool steel
 - high speed steel
 - cast iron
- 16.____ The grit of a grinder wheel is determined by the:
- diameter
 - size of the abrasive particles
 - grinder make
 - material that may be ground
- 17.____ When hollow grinding is desired, the tool is moved _____ on the wheel.
- up and down
 - side to side
 - diagonally
 - vertically
- 18.____ If the cutting edges of a drill bit are not the same length, the hole will be:
- smaller
 - larger
 - oblong
 - tapered

Answer sheet, Unit Exam

1. A
2. B
3. A
4. D
5. D
6. A
7. C
8. C
9. A
10. A
11. B
12. B
13. B
14. A
15. B
16. B
17. B

Tool Sharpening List

The following lists of tools are those which are to be sharpened by the student in order to complete the exercise for this lesson. Each student **MUST** sharpen one tool in sections A, B, and C. Tools in section D are exactly what they are, extra credit. No extra credit tools may not be substituted for required tools. Required tools must be completed before extra credit assignments are accepted.

A. DRILL BIT

B. CONVEX GRIND

SPLITTING MALL

AXE

HATCHET

C. HOLLOW GRIND

WOOD CHISEL

COLD CHISEL

CENTER PUNCH

D. EXTRA CREDIT

PIN PUNCH

DRIFT PUNCH

FIT A HANDLE ON A TOOL

* POCKET KNIFE

* ONLY LEGAL KNIVES AS PER OUR DISCUSSIONS ALREADY. ANY ILLEGAL KNIVES OR QUESTIONABLES WILL BE CONFISCATED. USE YOUR JUDGEMENT AND COMMON SENSE.

Name _____

Date _____

Tool Sharpening Score Sheet
(75 Points)

A. TWIST DRILL

correct lip angles _____

correct clearance angles _____

cutting lips the same length _____

workmanship _____

TOTAL POINTS _____

B. CONVEX GRINDING EXERCISE

square on the tip _____

symmetrical on both sides _____

correct angle _____

correctly convex ground _____

workmanship _____

TOTAL POINTS _____

C. HOLLOW GRINDING EXERCISE

square on the tip _____

correct angle _____

correctly hollow ground _____

whetstone finish _____

workmanship _____

TOTAL POINTS _____

ANY EXTRA CREDIT _____

GRAND TOTAL _____

Grinding Wheels

Position	1	2	3	4	5	6
(Prefix)	Kind of Abrasive	Grain Size	Grade of Hardness	Structure	Bond Type	Manufacturer's Record
Example 32	A	46	H	8	V	BE
Manufacturer's symbol indicating exact kind of abrasive	A-Aluminum Oxide C-Silicon Carbide	course 10 12 14 15 20 24 medium 30 36 46 54 60 fine 70 80 90 100 120 150 180 very fine 220 240 280 320 400 500 600	Soft to Hard A soft B C D E F G H I J K L M N O P Q R S T U V W X Y Z hard	Dense to Open 1 dense 2 3 4 5 6 7 8 9 10 11 12 13 14 15 hard	V-Vitrified S-Silicate R-Rubber B-Resin E-Shellac O-Oxychloride	Manufacturers' private marking to identify wheel. May be a letter or number or both to designate modification of bond or wheel characteristics
(use is optional)				use is optional		(use is optional)

SHARPENING A DRILL BIT

STARTING POSITION

1. Hold the cutting end of the drill between thumb and forefinger of right hand with 1 inch of the drill bit exposed. Lay the forefinger on the grinder rest. The finger will be kept stationary and should not be lifted from the grinder rest during sharpening
2. Hold the shank of the drill between thumb and forefinger of the left hand.
3. The cutting edge of the drill should be parallel to the top of the grinder rest as in figure F-2.

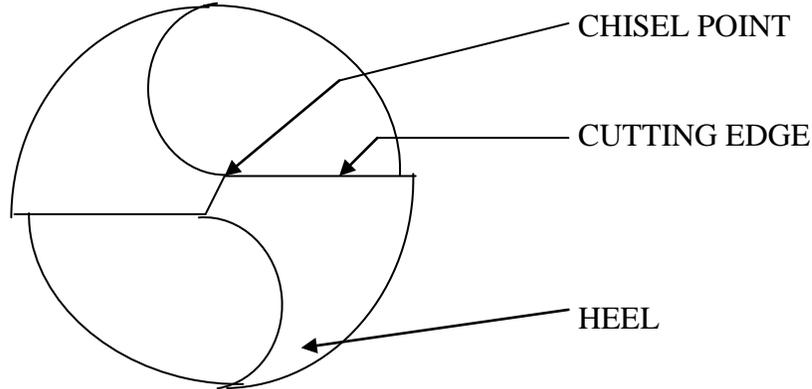


Figure F-1

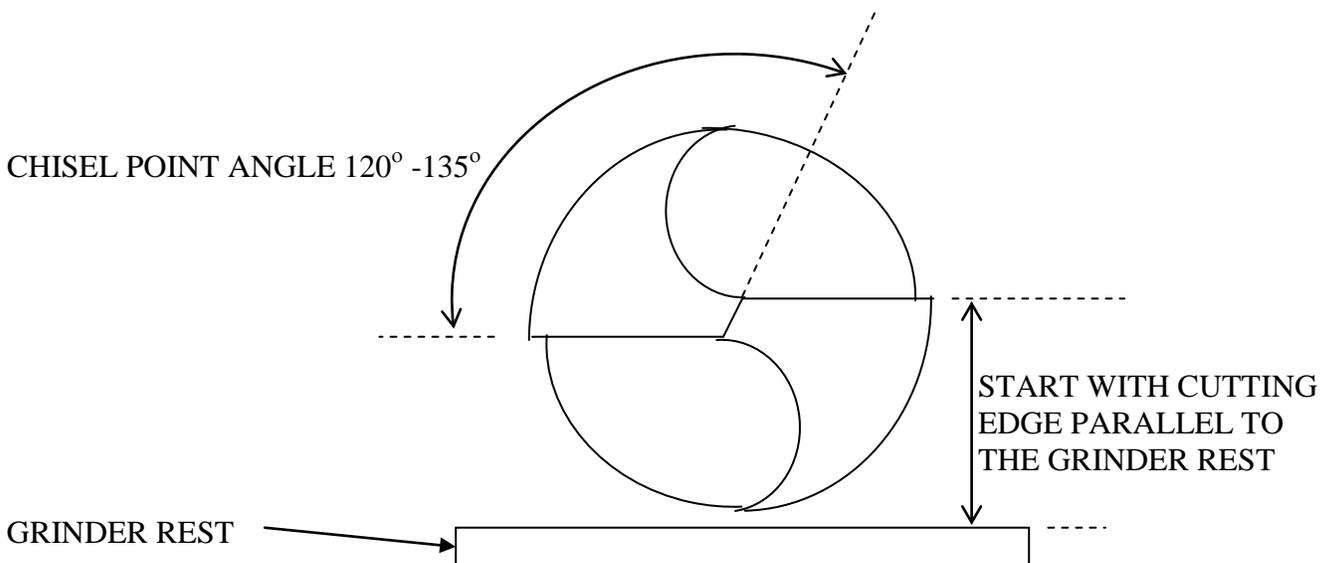


Figure F-2

4. The drill should be held at a 59° angle to the centerline of the grinding wheel as in figure F-3.
5. The centerline of the drill should point slightly above the center of the grinding wheel as in figure F-4.

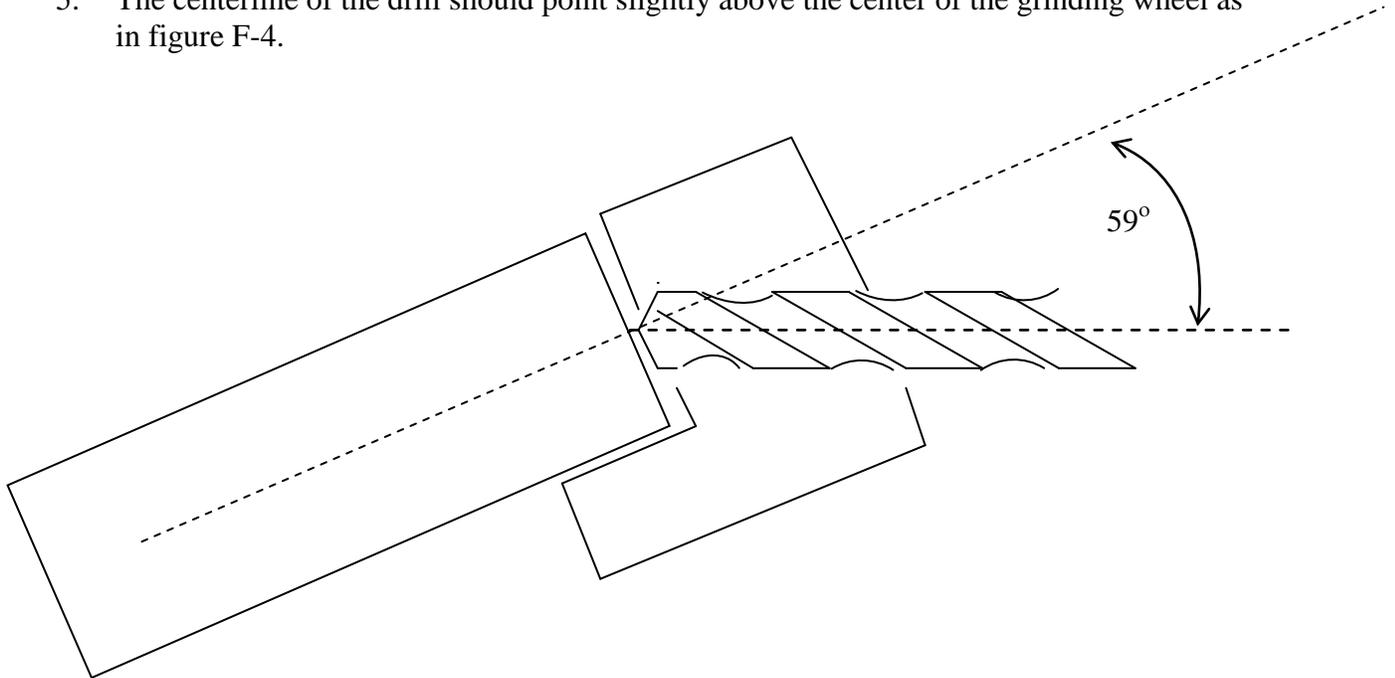


Figure F-3

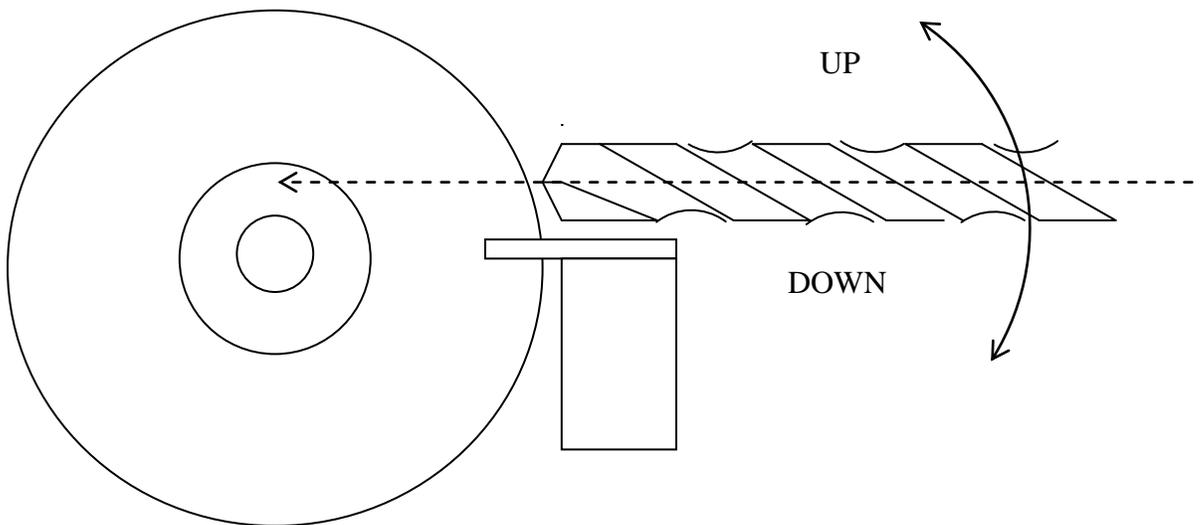


Figure F-4

GRINDING THE DRILL

Move the drill to the stone and as the grinder makes contact, rotate the left thumb and forefinger down to the left. The knuckle of the left forefinger act as a pivot point and should not move up or down but it will rotate. The drill will rotate about 1/6th of a turn because of this motion. Do not rotate the drill between left thumb and forefinger as this would cause rotation of more than 1/6th of a turn and will cause an S-shaped chisel point. An S-shaped chisel point decreases the length of cutting edges and requires excessive pressure while drilling.

Repeat this grind, alternating between cutting edges, until the cutting edges are sharp, both cutting edges make a 59° angle with the axis of the drill, lengths of both cutting edges are equal, and there is an 8° to 12° lip clearance as in figure F-5. The chisel point should be straight and from a 120° to 135° angle with the cutting edges as in figure F-2.

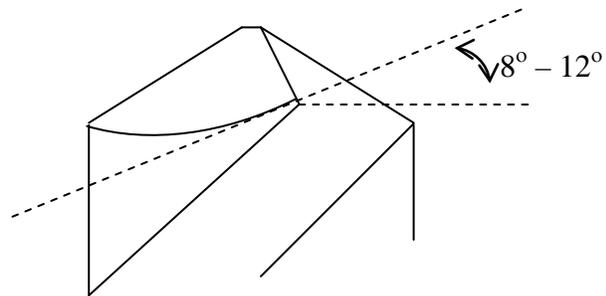


Figure F-5

CORRECTING FAULTS OF TWIST DRILL SHARPENING

Faults	To Correct
Unequal length of cutting edges.-----	Grind short edge more.
Not enough lip clearance.-----	Move shank towards DOWN (Fig. F-4) at start of grind.
Too much lip clearance.-----	Move shank towards UP (Fig. F-4) at start of grind.
S-shaped chisel point.-----	Do not rotate drill as much.
No lip clearance at chisel point.-----	Not enough movement to left. (Fig. F-2)

OTHER HINTS

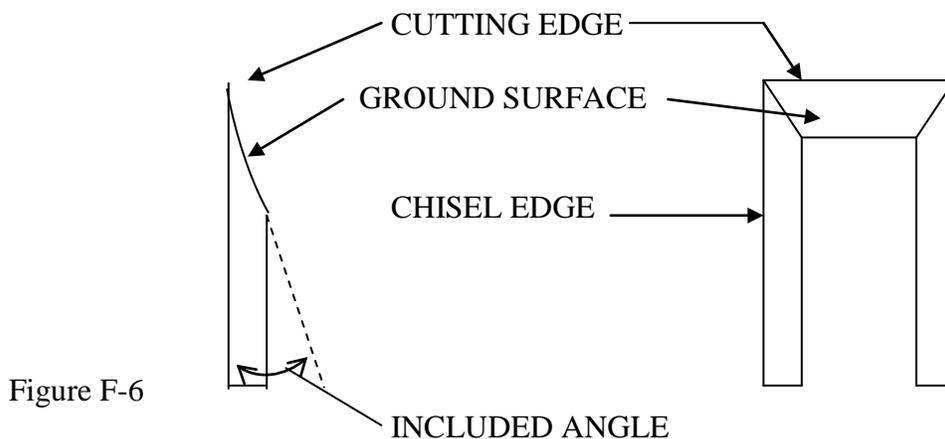
Use a bar of Ivory soap as a substitute for metal. Cutting the soap with a drill bit held in the hand will effectively demonstrate the proper cutting of a drill bit. It is difficult to remove even soft soap with a drill bit that lacks lip clearance.

Make sure grinder guards are in place while grinding.

SHARPENING A WOOD CHISEL

Steps in removing a wood chisel:

1. Remove the nicks and square the cutting edge to right angles with the sides or edges of the chisel
2. Grind the chisel to an included angle of 25° - 30° between the ground surface and the back of the chisel.
3. Hone the chisel to an included angle of 30° - 35° between the honed surface and the back of the chisel.



Procedure in Sharpening a Wood Chisel

Step 1: Necessary only when the cutting edge is nicked. When this step is required the cutting edge is ground so as to remove the nicks and the cutting edge is ground to right angles with the edges of the chisel.

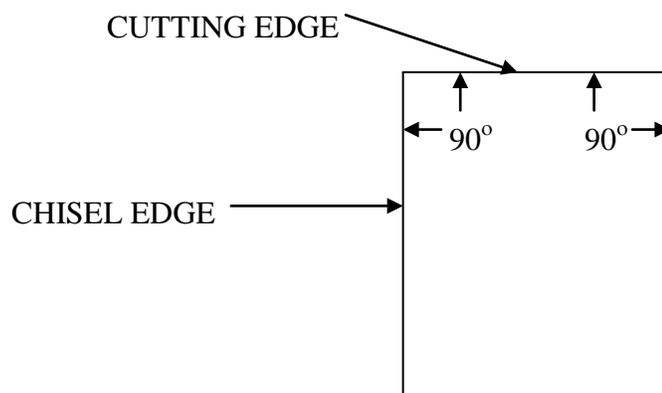


Figure F-7

Step 2: Grind the beveled surface so that the included angle will equal $25^{\circ} - 30^{\circ}$. This will be a suitable angle for most work although the angle may be decreased for light work and increased for heavy work such as with hardwoods.

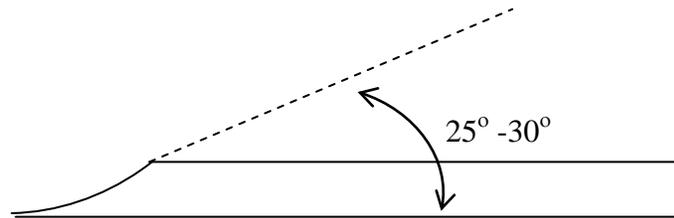


Figure F-8

Grinding on the face of the grinding wheel will result in the chisel being hollow ground. Keep the grinding wheel dressed so as to have a good cutting surface on the grinding wheel which causes a minimum of friction and prevents burning of the chisel.

Using the tool rest, grasp the chisel at a location on the chisel so that running the chisel on the tool rest and the forefinger against the tool rest edge will result in the proper angle being ground. Moving the grip towards the cutting edge will provide a greater included angle and moving the grip towards the handle will decrease the included angle.

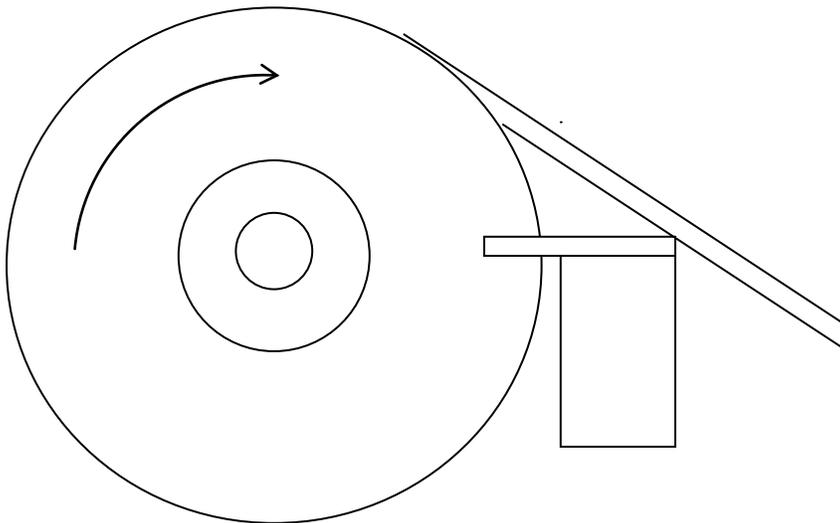


Figure F-9

An angle formed by the cutting edge and the right side of the chisel which is less than 90° is caused by the sharpener rotating the chisel counter-clockwise or swinging the handle to the right as in figure F-11.

An angle formed by the cutting edge and the left side of the chisel which is less than 90° is caused by the rotating the chisel clockwise or by swinging the chisel to the left as in figure F-12.

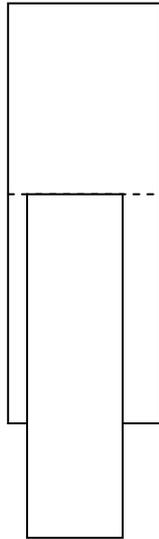


Figure F-10

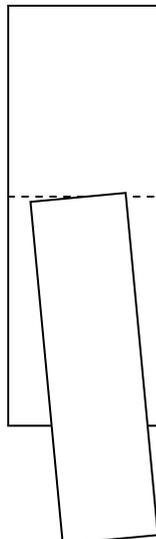


Figure F-11

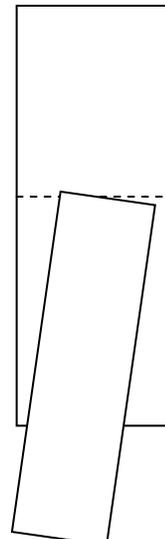
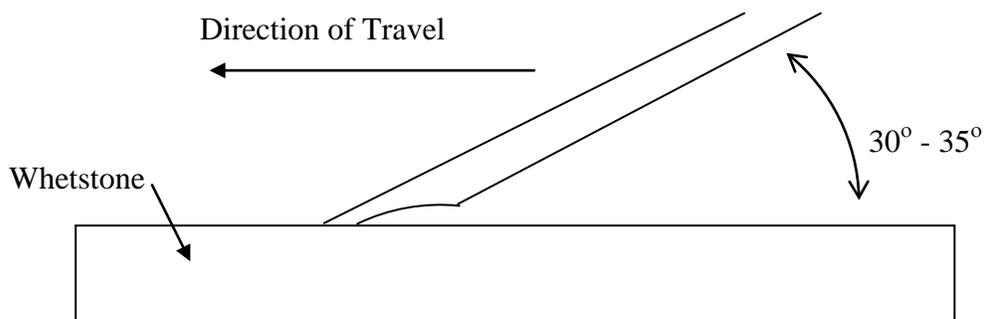


Figure F-12

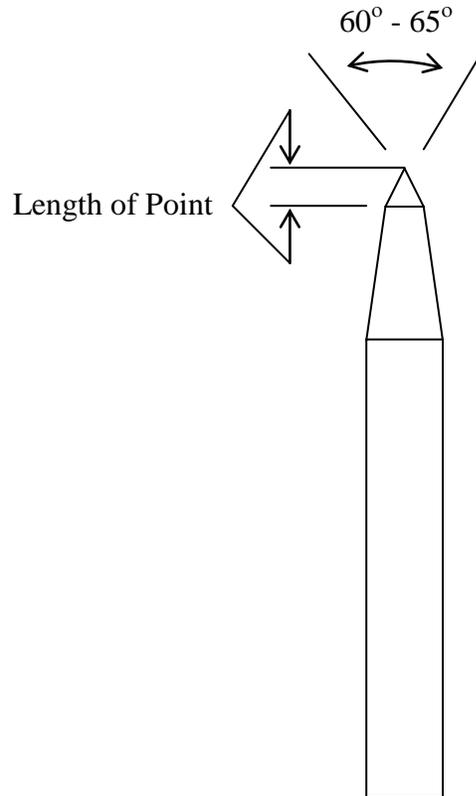
Step 3: Hone the cutting edge to a $30^\circ - 35^\circ$ included angle.



After taking 3 to 4 strokes on a fine stone check for a burr by drawing the pad of your finger over the cutting edge in the opposite direction of cutting. As honing progresses, a point is reached where the two surfaces of the cutting edge meet at a very fine line and become so thin that it starts to peel back and this causes the formation of a burr or wire edge. Place the flat side of the chisel on the stone and pull it toward you. One or two strokes should snap off the burr.

130F-25

SHARPENING A CENTER PUNCH



SPECSIFICATIONS

Single Face
Face Hollow Ground
 $60^\circ - 65^\circ$ Point
Point to be Centered
Length of Point Not to Exceed $1/4''$

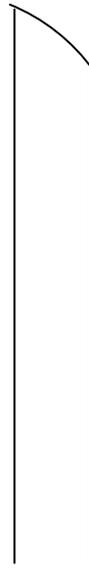
Hint

Grind the same as you would a wood chisel.

HOLLOW GROUNG



CONVEX GROUNG



130G-1

PLUMBING AND PIPE FITTING

130-G

UNIT OBJECTIVE

After completion of this unit, students will be able to properly identify plumbing materials, perform plumbing installations, and exhibit safe handling and working practices with plumbing tools and equipment. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Properly identify plumbing materials.
2. Understand the purposes for the various plumbing materials.
3. Understand the purposes for the various plumbing fittings and materials.
4. Properly identify plumbing tools and materials.
5. Perform an installation, including cutting pipe to length and installing fittings, using a combination of materials, including steel, plastic, and copper.
6. Exhibit safe handling and working practices with plumbing tools.

PLUMBING MATERIALS

A. Plumbing systems supply water and take away wastes by routing pipes to and from fixtures or appliances. Plumbing is a two-part system:

1. The water supply system carries fresh (potable) water from a source such as a well or street main to a fixture.
2. The Drain-Waste-Vent (DWV) system carries excess water and waste away to a septic system or municipal waste treatment center.
3. Plumbers and pipefitters are people who install and repair plumbing systems.
4. The Uniform Plumbing Code (as well as local plumbing codes) should be followed when installing pipes, fittings, and fixtures in order to provide a safe operating system.
5. In agriculture, many liquids in addition to water (e.g., milk, soybean oil) are carried through specially designed pipes to points of storage and processing.

B. Plumbing the Home and Farmstead

1. Designing a plumbing system for the home and/or farmstead requires a knowledge of and familiarity with plumbing materials.
 - a. A pipe is any rigid tube like material.
 - b. Tubing is any pipe that is flexible enough to bend.
 - c. A nipple is a short pipe under 12 inches in length.
 - d. A fitting is a connecting device used to join pieces of pipe or to connect pipe to other objects such as fixtures, appliances, or pumps.
 - e. The size of pipe is generally based on the inside diameter (ID) which is a nominal size, not the actual size. However, the outside diameter (OD) may occasionally be used to measure the size of the pipe.
2. In agricultural mechanics, most work completed with pipe and pipe fittings may be considered to be a part of plumbing.

C. Material Identification in Plumbing Construction Pipes

1. Steel pipe is available in three grades: standard (sch 40, wall thickness in inches), extra strong (sch 80), and double extra strong (sch 120).
 - a. Extra strong (sch 80) and double extra strong (sch 120) are used primarily in commercial and industrial settings.

130G-3

- b. All grades of steel pipe have the same outside diameter for a given size which permits pipe threading with the same die; it also allows the use of the same sized pipe fittings for all three pipe grades. The additional wall thickness results in reduced inside diameters.
2. Two types of steel pipe are primarily used in plumbing: black iron and galvanized steel. (**Show Examples** if you have any)
- a. Black iron pipe is used for gas, steam, and emergency fire systems.
 - b. Black iron pipe has no coating; therefore it provides little resistance to rust. When used for underground gas lines, black iron pipe comes with a Poly-Vinyl-Chloride (PVC) coating to protect it from corrosion.
 - c. Before 1970, galvanized pipe was used mainly for water supply and cold water systems. It is still used in combination with other materials because of its strength and ability to support cantilevered weight (such as hand rails and bike racks).
 - d. Galvanized pipe will meet the minimum pressure requirement of 125 psi when standard (sch 40) is used.
 - e. Galvanized pipe not only creates greater friction losses than copper and plastic pipes do, but it also has a greater tendency to scale and thus it reduces flow capacity.
 - f. Galvanized pipe lasts at least 30 years in most soils, where as black pipe would last less than 10 years.
3. Connecting steel pipe in plumbing construction requires two types of fittings: threaded and dielectric fittings.
- a. Threaded fittings are tapered threads which create an interference fit that should not be used in combination with other threads such as machine or hose threads.
 - 1) Threaded fittings are extremely time consuming to make.
 - 2) Threaded fittings require some type of pipe thread compound such as pipe joint compound or Teflon tape to create a water tight seal.
 - b. Dielectric (nonconducting) fittings (couplings or bushings) are necessary when dissimilar pipes are used in combination with copper pipe or tubing in order to minimize electrolysis (dissimilar metals causing a chemical reaction) which causes corrosion.

4. Additional Standard Information Regarding Steel Pipe

- a. The standard length of steel pipe is 21 feet.
- b. Steel pipe is sized according to the nominal ID.
- c. Steel pipe is the best material for resisting mechanical or fire damage.
- d. Water quality should be considered before selecting pipe materials. Investigate the local plumbing code.
- e. Galvanized pipe nipples can be purchased in half-inch increments up to 6 inches and 1-inch increments from 7 to 12 inches.

5. Copper pipe is available in two types: rigid pipe and flexible tubing. It is used in water supply and Drainage-Waste-Vent (DWV) systems. (**Show Examples** if you have any)

- a. Rigid copper pipe is available in four wall thicknesses and is color coded.
 - 1) Thin-walled (type M-red) is usually adequate for home plumbing.
 - 2) Medium-walled (type L-blue) is generally used for commercial plumbing.
 - 3) Thick-walled (type K-green) is used on outside work that may be subject to mechanical damage or for underground burial.
 - 4) Drainage-Waste-Vent (DWV-yellow) may be used in any DWV system. This is the thinnest-walled form of copper pipe.

b. Additional Information Regarding Rigid Copper Pipe

- 1) Rigid copper pipe diameter is measured by the nominal ID.
- 2) The OD is a given nominal size which remains the same for all four weights of pipe.
- 3) Rigid copper pipe is sold in standard 10 and 20 foot lengths.
- 4) Rigid copper pipe can be soldered only; it cannot be flared.
- 5) Rigid copper pipe, although comparatively expensive, is easy to work with in both new installations and modified systems. The savings in labor will generally offset the high cost of materials.

- c. Flexible copper tubing, unlike rigid copper pipe as described above, is not color coded. However, it is graded according to two types of wall thicknesses and is marked every eighteen inches with its type and manufacturing information.
 - 1) Medium-walled (type L) is used in most homes, principally for gas service lines.
 - 2) Thick-walled (type K) is used in most homes for underground water service lines.
 - 3) There is no thin-walled or DWV type of flexible copper tubing.
 - 4) The chief advantage of flexible copper tubing is its flexibility; it can easily be bent across the knee. However, care must be taken to avoid kinking.
 - 5) Flexible copper tubing is resistant to most corrosion.

- 6. Plastic pipe, similar to copper pipe, is available in two types: rigid pipe and flexible tubing.
 - a. Rigid pipe is manufactured out of three different synthetic products: PVC, ABS, and CPVC. (**Show Examples** if you have any)
 - 1) PVC (polyvinyl chloride) is used primarily for cold water supply, DWV, and irrigation lines.
 - 2) ABS (acrylonitrile butadiene styrene) is used exclusively for DWV systems.
 - 3) CPVC (chlorinated polyvinyl chloride) is used in hot and cold water supply. Although it costs three to four times more than pvc it normally is used because it withstands heat and maintains its strength. The local plumbing code should be checked prior to CPVC installation.

 - b. Plastic rigid pipe is available in three weights: schedule 40, 60, and 80; all weights meet the minimum pressure rating of a closed water system. (Other lighter weight [ie. class 125] pipe is also available, but it should be used only for landscape irrigation purposes.)

 - c. Additional Information Regarding Rigid Plastic Pipe
 - 1) Rigid plastic pipe is sized according to its nominal ID.
 - 2) Rigid plastic pipe is available in standard 20 foot lengths.
 - 3) The OD remains constant while the ID varies according to weight; this allows the use of the same fittings.

130G-6

- 4) All types of rigid plastic pipe can be joined to their respective fittings by using an appropriate solvent cement (solvent-welded) for the job. Time and temperature play an important role in getting a good seal.
- 5) Local codes generally forbid the use of rigid plastic pipe behind or within walls. Sch 80 is recommended for out-of-ground exposed work.

d. Flexible plastic tubing is available in only two types of synthetic material: PE (polyethylene), commonly used in landscape drip irrigation, and PB (poly-butylene), a relatively new material used indoors for hot and cold water supply systems.

e. Additional Important Information Regarding Flexible Plastic Tubing

- 1) The inside diameter of flexible plastic tubing remains constant while the outside diameter varies according to the quality.
- 2) Flexible PE tubing can be used only for outside cold water systems such as wells or sprinklers.
- 3) Flexible plastic tubing is connected to itself or steel pipe by using polystyrene fittings and couplings. Stainless steel base clamps are used to secure the slip joints. Solvent is not used.
- 4) There are several advantages to working with flexible plastic tubing: low material cost, ease and speed to work with, and flexibility.
- 5) Flexible plastic tubing does not normally corrode; however, it will deteriorate with extended exposure to direct sunlight. If it is not exposed to direct sunlight, flexible plastic tubing has a long life expectancy.
- 6) Flexible plastic tubing creates less friction loss than metal pipes do.

D. Identification of Miscellaneous Material Used in Plumbing Construction:

1. Steel pipe requires the application of a sealant to ensure a leakproof fit.
 - a. Pipe thread compound, which commonly contains Teflon, is used on the threads of pipes to prevent leaks.
 - b. Teflon tape can be used as an alternative to pipe thread compound.

2. Solder is the medium used to join copper pipe and fittings.
 - a. Solder comes in a variety of types. 50-50 solder is a combination of 50% tin and 50% lead and is suitable for moderate temperature and pressure. If a stronger joint is required, 95-5 solder (which is 95% tin and 5% antimony,) may be used.
 - b. 50-50 solder is no longer allowed for use in water supply systems because of its lead content. Therefore, check the local plumbing code, and use a lead-free solder such as 95-5 where appropriate.
 - c. Flux is necessary to remove oxides, promote wetting, and protect surfaces during heating. It should not be relied upon to clean the surfaces of copper pipe and fittings. Manual cleaning is required.

3. Plastic pipes and fittings are joined by a solvent weld joint.
 - a. Primer is essential for a solvent weld joint in plastic pipe. Priming cleans the surface, removes glaze, and starts the softening process to make a proper joint. Use the appropriate primer for the type of plastic pipe being used.
 - b. Solvent glues or cements are available for ABS, PVC, CPVC plastic pipe. Use the appropriate type for the pipe being used. All purpose or universal solvent glues are convenient to use when using more than one type of plastic pipe.

ACTIVITY:

1. Take a short tour of the school grounds and identify the types of plumbing materials found.
2. Visit an agricultural enterprise and observe the types of plumbing materials used for supplying water and carrying away various wastes.
3. Find exposed plumbing at home and identify the types of material used by application.

FITTING

A. Plumbing fittings have different shapes which allow rigid straight pipe to change both direction and diameter. Since the names of plumbing fittings derive from either their shape or their function, the names remain the same regardless of the material from which they are made. Fittings are generally divided into two categories: water supply or DWV. A description of the most common plumbing fittings follows:

1. Elbows are used to change the angle or direction of the pipe run. The most common elbows come in 90 degree and 45 degree turns. The sweep of the fitting describes how fast a transition or change in direction is made. Therefore--especially in DWV fittings--the long sweep fittings are chosen to avoid clogs. 90 degree elbows are generally called ells.
2. On street elbows, one end of the fitting has male threads and the other end has female threads. Street elbows are common in galvanized steel and copper pipe. They are convenient because they do away with the need for a nipple and work well in tight quarters.
3. Tee or T-fittings allow for branch lines. They are shaped like the letter T. DWV tees are known as waste or sanitary Ts. In these fittings the intersection is slightly curved in order to avoid clogs. Gradual bends are best for smooth flow of waste.
4. Couplings are used to join two straight pieces of pipe of the same diameter.
5. Reducers are used to join pipe of different diameters. Galvanized steel reducers are called bell reducers because they look like a bell. All reducers make a gradual transition between different diameters of pipe and therefore they take up considerable space.
6. Bushings are used to make the diameter of a pipe fitting smaller. They differ from reducers in that they make abrupt changes in diameter and take very little space. Two examples of galvanized steel bushings are face bushings, which take the least amount of space, and hex bushings which can be tightened with an adjustable wrench.
7. Unions are used to join pieces of pipe where pipes cannot be turned or when a piece of equipment may have to be removed for maintenance or replacement.
8. Adapter fittings are used to change the end of a non-threaded pipe to male or female threads as needed. Adapters are commonly used in copper and plastic plumbing jobs.
9. Caps are used to close the end of a dead end pipe.
10. Plugs close an opening on a pipe fitting normally used for inspection and clean out.

11. Nipples are short lengths (under 12") of pipe threaded at both ends.
12. Wyes (pronounced like the letter Y) are used primarily to gain inside access to DWV systems.

B. Valves and Hose Bibs - Valves are used to control the flow of water or other fluids in a plumbing system. Common types of valves include the following:

1. A gate valve is a valve situated between the point of connection and the rest of the plumbing system.
 - a. It usually remains wide open, but can be shut down in case repairs or additions have to be made to the system.
 - b. A gate valve is not designed to be opened and closed on a regular basis. It has a movable wedge that is turned via a handle and spindle to regulate the size of the opening.
 - c. Repairs are simple. Remove the handle and packing nut and replace the packing washer. Reassemble and install. Remember to check for leaks. Do not overtighten the packing nut.
2. A check valve allows the fluid in the pipe to flow in one direction only.
 - a. Check valves are used in water wells to prevent the backflow of water.
 - b. There are two basic types: swing or flapper and lift check valves. Both work automatically.
3. A globe valve is a valve used when frequent adjustment of the flow rate is necessary.
 - a. It is a compression-type valve with a disk or washer that is compressed into a seat to form a tight seal.
 - b. Repair is made by replacing the stem washer or disk.
4. A hose bib is a threaded exterior faucet that allows for the attachment of a garden hose or appliance hose. It can also be called a sillcock or hosecock.

ACTIVITY:

1. Make a collection of pipe fittings for a display board.
Use steel, copper, and plastic examples.
2. Disassemble and compare a gate valve and a globe valve.
3. Repair a leaking hose bib.

PLUMBING TOOLS

Many different kinds of tools are used in plumbing. Steel, copper, and plastic are the most common plumbing pipe materials. Common and specialized tools needed to safely and efficiently work with plumbing materials are described below.

A. Measurement and Layout Tools

1. Steel tapes come in a variety of lengths; the ones most commonly used in plumbing are 50 and 100 feet long.
2. A tape measure has a retractable steel blade and comes in 8, 10, 12, 16, and 25 foot lengths.

B. Benches and Vises

1. A pipe vise is the preferred tool to use to hold steel pipe in place for cutting, reaming, and threading. It can be mounted on a portable tripod stand for field use.

NOTE: A machinist's vise should not be used to secure pipe unless it has a set of pipe jaws in addition to the regular jaws. Trying to hold round pipes in the straight-edged jaws of a machinist's vise can lead to slippage of the pipe if the jaws are secured too loosely and flattening of the pipe if the jaws are secured too tightly.

2. A plumber's bench is used to support large diameter steel pipe when cutting, reaming, and threading.
3. An adjustable pipe support stand has a concave roller and is used to support the free end of a long length of pipe; it is especially useful in conjunction with a portable pipe threading machine.

C. Cutting and Threading Tools for Steel Pipe

1. A hand-held wheel-type pipe cutter is used to cut steel pipe. It is rotated around the pipe and progressively tightened. The material is pushed to either side of the cutting wheel which leaves a large ridge or burr which must be removed.
2. A pipe reamer is used to remove the ridges or burrs from the inside of pipe; it can be fluted or spiral in design.
3. A portable pipe threading machine contains a powered head and can be used to cut, ream, and thread small diameter steel pipe.
4. A half-round file is used to deburr large diameter pipe and works well on all materials.
5. Oilers are containers with a pump and nozzle used to apply cutting oil when cutting threads in steel pipe.

6. Pipe dies are used to cut threads on steel pipe. A special tapered thread commonly known as National Pipe Thread (NPT) or as American Standard Taper Pipe Thread is used to provide a leakproof joint. NPT is tapered 3/4" per foot. Since pipe fittings come threaded, the plumber needs to cut only external (male) threads on the steel pipe. Sometimes a pipe tap is used to clean up internal (female) threads on used or damaged fittings. A die stock is a handle that holds the die in place.

D. Cutting, Cleaning, Soldering, Flaring, and Bending Tools for Copper

1. Copper tubing cutters come in various designs for large and small diameter copper pipe and tubing. Many have a built-in reamer. Midget tubing cutters cut copper pipe in close quarters.
2. A combination inside-outside reamer is convenient for 1/4 to 1 1/2" copper tubing. It is less awkward when preparing many joints. Large diameter copper pipe may also be reamed with a half-round file.
3. Copper fitting brushes are used to clean the inside diameter of fittings. Commonly available sizes are 1/8 to 2 1/2" brushes. They are handy when doing new construction where many joints must be prepared.
4. Copper tubing brushes range in size from 1/8 to 1 inch and are used to clean the outside diameter of copper pipe. Normally copper pipe over 1 inch in diameter is cleaned with abrasive sandcloth.
5. A propane torch is commonly used for minor plumbing repairs. It is used to heat the pipe and fittings. Small throwaway cylinders make this style of torch convenient for small jobs.
6. Acetylene or propane refillable cylinders are common for large soldering jobs. A regulator, hose, and torch body make up the kit.
7. A friction igniter or striker is used to light the torches above.
8. A yoke and screw flaring tool is used when flared-style fittings join fixtures or copper tubing. After the tubing is cut and reamed, a flange nut is slipped over the tube. Then the yoke is tightened to secure the tube. The screw with its cone-shaped end is tightened to produce a 45 degree flared end.
9. A swage (swedge) or hammer-type flaring tool can be used to flare soft copper tubing. They come in diameters ranging from 1/4" to 1."
10. A spring bender is used to bend soft-tempered copper with outside diameters ranging from 1/4 inch to 7/8 inch.
11. A lever-type bender is used to bend small diameter (3/16 inch to 1/2 inch) copper tubing.
12. Pipe benders come in various designs and sizes and can be used on large-diameter (5/8 to 7/8 inch outside) hard drawn copper tubing.

E. Cutting and Reaming Tools for Plastic Pipe

1. A plastic tubing cutter is used to cut Poly-Ethylene (PE) or Poly-Butylene (PB). It operates like a pair of shears.
2. Tubing cutters are primarily designed for copper, but they also work well with plastic.
3. A blade-type cutter works similar to a tubing cutter, but uses a replaceable blade rather than a cutting wheel.
4. Hacksaws have replaceable blades and work well for cutting small diameter (2" or less) plastic pipe as long as care is taken to make a square cut.
5. Plastic pipe inside-outside reamers come in various sizes. A pocket knife or half-round file works equally well for deburring plastic pipe.

F. Assembly Tools - Wrenches and pliers are used to tighten fittings and turn pipe. Finishing assembly tools have smooth jaws in order not to mar fixtures or decorative nuts with chrome plating. The following is a partial list:

1. Straight pipe wrenches come in a variety of sizes and materials. Aluminum is popular and reduces fatigue because it is 40 percent lighter than malleable cast iron pipe wrenches.
2. End pipe wrenches are used in tight locations. They also come in a variety of sizes.
3. Chain wrenches and chain tongs are used to tighten iron and steel pipe. They distribute the biting force evenly around the pipe without crushing it and can be used in close quarters.
4. Monkey wrenches come with smooth jaws and are used to tighten square and hexagonal fittings.
5. Adjustable open-end wrenches (also known as crescent wrenches) have smooth jaws and can be used in finish work.
6. Multi-joint pliers (also known as water pump or channel lock pliers) are used with plastic pipe and for a variety of other applications.

G. Miscellaneous Plumbing Tools

1. A plunger clears drain clogs with air pressure and water.
2. A snake is a flexible steel cable rotated and pushed through a pipe to unseat a clog.
3. A jab saw is used to cut off water closet bolts; it can be useful in tight spots where a hacksaw would be handy.
4. A basin wrench is used to extend behind fixtures and tighten water supply connections.
5. A basket-strainer wrench is a specialized wrench used to tighten the basket strainer in a kitchen sink.

Activities:

1. Set out plumbing tools and materials and have students identify them, checking to be sure they use the correct names.
2. Choose the appropriate tools to use with each type of pipe and then practice cutting, reaming, threading various sizes of steel, copper, and plastic pipes.

INSTALLATION OF A PLUMBING PROJECT

SAFETY IN PLUMBING WORK

Observe the following general safety practices in doing all plumbing work.

1. Be sure the system is not electrically charged. If a hot or shorted wire is touching any part of the metal plumbing system, the shock can kill anyone who touches it. Thawing frozen water pipes with an arc welder can create shock as well.
2. Wear safety glasses. When plumbing, protect your eyes.
3. Wear hard hat and safety shoes. These protect against blows from heavy objects, bursting pipes, and solvents which are used for soldering plastic pipe.
4. Cut off water pressure. Do this before repairing or adjusting the system.
5. Use a pipe vise. This is the safe way to hold pipe for threading.
6. Guard against burns. When using propane or butane torches for soldering, be careful not to burn yourself or the structure you are plumbing.
7. Guard against fire. In addition to being flammable, some plastic pipe soldering solvents are highly toxic and injurious to the skin.
8. Be careful when installing copper tubing in older buildings. When reworking the plumbing system in an existing structure, be careful not to touch hot electrical wires. If you are unaware of the presence of electrical service in the wall switch, turn the circuit breaker off until you have installed the copper pipe

* Reprinted by permission of Interstate Publishers, Inc., from MODERN AGRICULTURAL MECHANICS, 2nd ed., by Stanley R. Burke and T. J. Wakeman. Copyright 1992 by Interstate Publishers, Inc.

A. Installing a Plumbing Project

1. A drip irrigation system is one example of a plumbing situation that uses many different types of plumbing materials.
 - a. The typical control head for commercial-scale agriculture consists of sand filters and screen filters along with regulators and backflow devices.
 - b. The control head, because of its weight, requires the strength that steel pipe offers.
 - c. The control head may be strategically positioned with unions for easy removal and maintenance.

2. Distribution Lines

- a. PVC is the material most commonly used for mainlines and headers.
- b. Lateral lines are often PVC or PE.

B. General Procedures for Constructing a Plumbing Project

1. First make a working drawing for a small drip irrigation model. Then make a bill of materials and a cutting list prior to starting assembly of the system.
2. Measure and cut the various types of pipe to length.
 - a. Allow for threaded ends and fitting sockets when measuring overall length.
 - b. Use a pipe vise when cutting steel and copper pipe.
3. Ream and thread steel pipe. Ream and clean copper and plastic pipe.
4. Obtain the required fittings and clean them.
 - a. Prefit the pipe with fittings and make sure all parts are present before starting final assembly of the system.
5. Assemble the regulator, strainer, and backflow device with pipe nipples. Remember to place unions on each end.
6. Final Assembly
 - a. Lay out main line and laterals.
 - b. Use pipe joint compound for threaded fittings.
 - c. Solder any copper fittings included in the project.
 - d. Prime and glue plastic fittings.

- e. Allow the project to sit over night so the solvent weld joints (plastic) cure.
 - f. Clean up and prepare for system testing.
7. Test the project with water and check for leaks.
- a. Use a pressure gauge to measure flow pressure (dynamic) and available pressure (static).
 - b. Available pressure from the street water main or a well pressure tank generally ranges between 45-60 psi.
 - c. Never exceed 80 psi within any building.
 - d. Flow pressure for common plumbing fixtures range from 8 to 25 psi.
8. Review procedures and discuss other agricultural mechanics plumbing applications.

C. Specific Steps to Follow When Cutting and Threading Steel Pipe

1. Wear gloves when handling heavy pipe.
2. Measure and mark pipe.
3. Secure pipe in a pipe vise.
4. Align pipe cutter and tighten handle slightly. Rotate pipe cutter and tighten handle as needed until cut is completed.
5. Ream the inside of the pipe back to the original diameter.
6. Place the proper size die for the diameter of pipe in the die stock and thread the pipe by rotating the die. Lubricate and reverse the rotation slightly every 1/2 turn or so to break off the cutting.
7. Do not go past the end of the die housing.
8. Remove the die and wipe the thread clean.
9. Apply pipe joint compound to the male thread and start fitting by hand.
10. Complete the tightening with appropriate wrench.

D. Specific Steps To Follow When Cutting and Soldering Copper Pipe

1. Measure and mark the pipe.
2. Select the appropriate tubing cutter.
3. Secure pipe in pipe vise.
4. Align the cutting wheel on the mark and tighten handle slightly.
5. Rotate tubing cutter and tighten handle every 1/2-1 turn until pipe is cut.
6. Ream the inside of the pipe.
7. Clean the OD of the pipe with a tubing brush or sandcloth.
8. Clean the ID of the fitting with a fitting brush or sandcloth.
9. Wipe pieces clean.

10. Mark the pipe and fitting for its relative orientation.
11. Apply a small amount of flux over the area of contact between the pipe and the fitting. Wipe off excess flux.
12. Place the fitting in its proper relative position.
13. Light the torch and adjust the flame.
14. The approximate amount of solder to use is equal to the inside diameter of the pipe.
15. Apply heat to the tube momentarily. Allow heat to transfer to the end of the pipe. Move heat to base of fitting and place solder at the neck of the fitting. The solder will melt and be drawn into the fitting by capillary action when the temperature is correct. Do not use too much solder. It reduces the inside diameter. Do not overheat fitting.
16. Allow solder to become pasty and wipe fitting neck to remove excess solder.
17. Allow the pipe to cool.

E. Specific Steps to Follow When Cutting and Gluing Plastic Pipe

1. Measure and mark pipe for cutting and fitting orientation. A felt tip marker works well.
2. Cut pipe squarely by using a tubing cutter or miter box and saw.
3. Ream pipe by scraping ID with an inside-outside reamer or a pocket knife. Use sandcloth to clean any rough spots on the OD.
4. Check the interference fit with the fitting dry (trial run). The pipe should go in about halfway only.
5. Apply the primer to both pipe and fitting. Wait 5-15 seconds for the primer to soften and dull the finish.
6. Always apply solvent cement to the pipe and fitting.
7. Quickly insert the pipe in the fitting.
 - a. Make a 1/4 turn and align marks.
 - b. Make sure pipe bottoms out in socket.
 - c. Hold the fitting in place for 20 seconds or until the solvent begins to bond.
 - d. Check for a complete bead of cement around the fitting.
 - e. Wipe off the excess cement with a clean rag.
 - f. Allow the joint to cure for at least 30 minutes.
8. Wait overnight for the system to completely cure before testing.

ACTIVITIES:

1. Do the plumbing exercise in pipe fitting on page 130G-24,25.
2. Construct a small working model of a hog watering system with at least one gate valve and two nozzles (also known as lickets).
3. As a group, install an additional hose bibb or other necessary plumbing device at the school farm, land laboratory, or school shop.
4. Construct a small working drip irrigation model and inspect a commercial drip irrigation system.

References:

Burke, Stanley R., & Wakeman, T. J. (1990). MODERN AGRICULTURAL MECHANICS (2nd ed.). Danville, IL: Interstate Publishers.

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION Albany, NY: Delmar Publishers.

Editors of Reader's Digest. (1973). COMPLETE DO-IT-YOURSELF MANUAL (7th ed.). Pleasantville, NY: Reader's Digest Association.

Ripka, L. V. (1978). PLUMBING INSTALLATION AND DESIGN. Alsip, IL: American Technical Publishers.

McReynolds, Ray (1997) STEP BY STEP GUIDE BOOK ON HOME PLUMBING, Step-By-Step Guide Book Co. Salt Lake City, Utah 1-800-678-1500

RESOURCES:

Black and Decker Home Improvement Library. (1990). HOME PLUMBING PROJECTS & REPAIRS. Available from: Cy DeCosse Inc., 5900 Green Oak Drive, Minnetonka, Minnesota 55343 1-800-328-3895

Special Materials and Equipment:

Examples or a chart of different types of fittings, examples of different plumbing tools. Examples of different pipe materials, slides demonstrating installation of each type of material, examples of materials used to make joint connections. All materials necessary to construct a plumbing project of the instructor's choice; project should include steel, plastic, and copper materials.

Evaluation:

Tool Identification test by the instructor and oral review. Completion and testing of project.

Unit Exam

UNIT EXAM, PLUMBING

Circle the best answer.

1. Which of the following statements is correct?
 - a. A street elbow has one male thread and one female thread.
 - b. A bushing has two female threads.
 - c. A reducer has one male thread and one female thread.
 - d. A 90 degree elbow has two male threads.

2. The most common way to identify size of pipe is by:
 - a. Inside diameter
 - b. Outside diameter
 - c. Wall thickness
 - d. Pressure tolerance

3. The proper sequence for assembling PVC pipe is:
 - a. Prime, cut, glue, assemble
 - b. Cut, prime, assemble, glue
 - c. Cut, prime, glue, assemble
 - d. Cut, sand, glue, assemble

4. Soft 50-50 solder is a combination of:
 - a. Tin and lead
 - b. Tin and zinc
 - c. Gold and zinc
 - d. Silver and zinc

5. What type of threads are found on steel pipe fittings?
 - a. Straight pipe threads
 - b. Straight machine threads
 - c. Hose threads
 - d. Tapered pipe threads

6. A valve used for water supply systems to prevent backflow of water is the:
 - a. Gate valve
 - b. Globe valve
 - c. Check valve
 - d. Cock valve

7. Which pipe fitting would be used to fasten the ends of pipes where neither pipe can be turned?
- a. Coupling
 - b. Reducer
 - c. Bushing
 - d. Union
8. Soldering flux is not essential when sweat soldering copper pipe.
- a. True
 - b. False
9. When threading steel pipe, the pipe should extend beyond the die at least 1/2 inch.
- a. True
 - b. False
10. The standard length for steel pipe is:
- a. 10 feet
 - b. 12 feet
 - c. 15 feet
 - d. 20 feet
 - e. 21 feet
11. Bushing pipe fittings have:
- a. One male thread and one female thread
 - b. Two male threads
 - c. Two female threads
12. During the soldering process, the solder is distributed between surfaces of the bare metals by:
- a. Capillary action
 - b. Caterpillar action
 - c. Pressure
 - d. Osmosis
13. PVC stand for:
- a. Partial Value Code
 - b. Poly Vinyl Chloride
 - c. Poly Value Chloride
 - d. Partial Vinyl Chloride

14. Copper tubing can be joined by which of the following methods?
- a. Flare fittings
 - b. Sweating
 - c. Solvent welding
 - d. Both a and b
 - e. Both a and c
15. Steel pipe and copper pipe or tubing should never be connected directly together because of:
- a. Electrolysis
 - b. Hydration
 - c. Hydrolysis
 - d. Hydrocorrosion
16. Copper pipe is specified by its:
- a. Nominal outside diameter
 - b. Actual outside diameter
 - c. Nominal inside diameter
 - d. Actual inside diameter
17. Suppose a pump is to be removed from a plumbing system. Which of the following fittings allows the pump to be removed without disassembling the entire system?
- a. Adapter
 - b. Union
 - c. Bushing
 - d. Coupling
18. Drain-Waste-Vent (DWV) plumbing systems may be constructed with which of the following materials? (More than one answer can be circled)
- a. Copper
 - b. ABS
 - c. Cast Iron
 - d. Clay
19. Which of the materials listed below are used to assure a leakproof joint on tapered pipe threads? (More than one answer can be circled.)
- a. Teflon tape
 - b. PVC glue
 - c. Pipe joint compound with virgin teflon
 - d. Pipe dope

20. The primer used on PVC is to soften the plastic so the glue welds the two joints together stronger.

- a. True
- b. False

21. Which of the following materials can be used for natural gas lines?

- a. Galvanized steel
- b. Copper
- c. ABS
- d. Black steel

22. Galvanized steel pipe can be used only for cold water systems.

- a. True
- b. False

23. All three types of plastic pipe can be joined to plastic fittings by means of a special solvent cement (glue).

- a. True
- b. False

24. Plastic pipe can be cut with which of the following tools:

- a. Plastic pipe cutter
- b. Hacksaw
- c. Backsaw
- d. Tubing cutter
- e. All of the above

25. How many lengths of galvanized steel pipe do you need to order if you had to cut 14 faucet risers which were each 3 foot long? (SHOW ALL YOUR WORK!)

Answer Sheet- Unit Exam

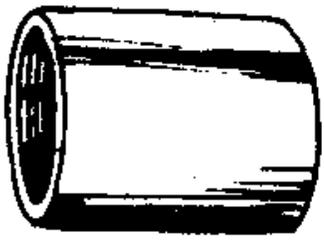
1. A
2. A
3. C
4. A
5. D
6. C
7. A
8. B
9. B
10. E
11. A
12. A
13. B
14. D
15. A
16. C
17. D
18. A,B
19. A,C,D
20. A
21. D
22. B
23. A
24. E
25. 2

Items Needed for Plumbing Project

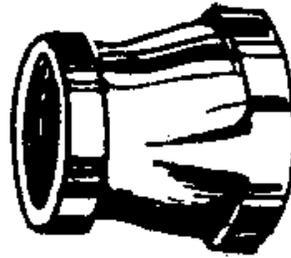
- 1/2" PVC pipe (12" per project)
- 1/2" PVC Tee slip by slip by treaded (1 per project)
- 1/2" PVC female adapter, slip by female treaded (1 per project)
- 1/2" PVC hose adapter, female (1 per project)
- 1/2" Sprinkler Head (1 per project)
- 1/2" Poly Cutoff Riser (1 per project)
- 1/2" Copper adapter, sweat by male treaded (1 per project)
- 1/2" Copper Tubing (12" per project)
- 1/2" Copper Cap (2 per project)
- 1/2" Copper Tee (1 per project)

Tools Needed

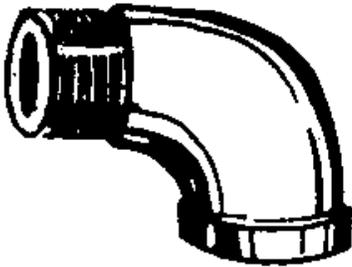
- Rosen Core Solder
- Solder Flux
- Steel Wool
- Tubing Cutters
- Butane or Propane Torch
- PVC Pipe Cutters or Hacksaw
- PVC Glue
- PVC Primer



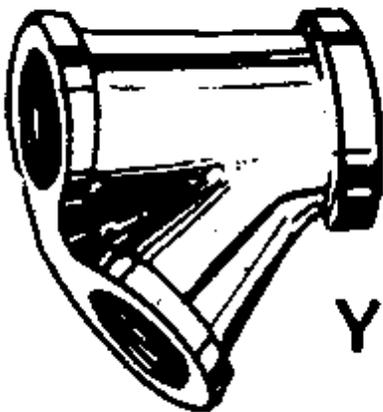
Coupling



Bell Reducer



90° Street Elbow



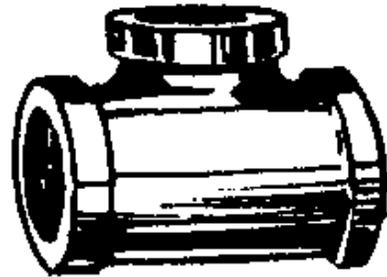
Nipples



Floor Flange



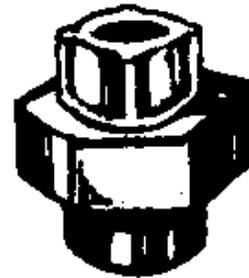
Plug



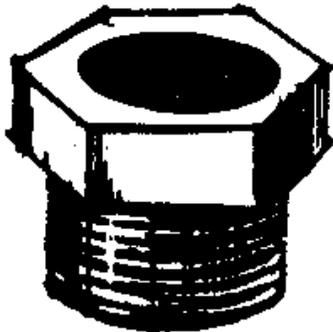
T



45° Elbow



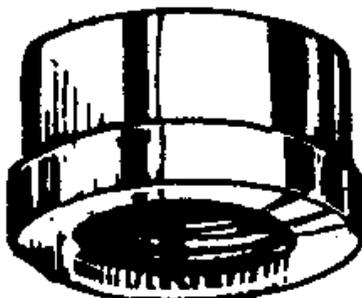
Union



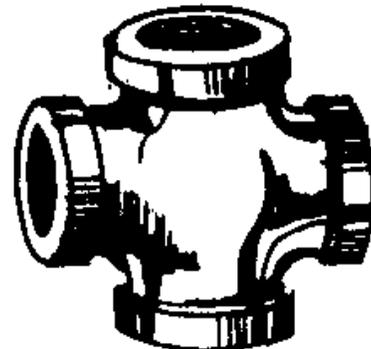
Bushing



90° Elbow



Cap



Straight Cross

130H-1

WOODWORKING

AG 130-H

UNIT OBJECTIVE

After completion of this unit, students will be able to measure, mark, cut, and assemble wood projects and operate woodworking tools safely. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Select kinds, grades, and quantity of lumber for a given task.
2. Identify and demonstrate the uses of ten different woodworking hand tools.
3. Measure and mark wood for cutting and drilling.
4. Cut and assemble wood parts.
5. Know the basic joints used in woodworking and demonstrate the application of two.
6. Operate power tools correctly and safely, replacing blades and making adjustments as necessary.

SELECTING WOOD AND LUMBER

A. Kinds of Wood

1. Softwood comes from needle-leaf, evergreen trees called conifers.
 - a. White pine--which is easy to work with and straight--is used for shelving, interior finish, exterior trim, and door frames.
 - b. Yellow pine--which is wear resistant and tough--is used for benches, stairs, and other places where a semi-hard surface is desired.
 - c. Fir--which is light, straight, and strong--is used for framing members (dimension lumber), siding, sheathing, and gates.
 - d. Redwood--which has excellent decay resistance--is used for posts, fences, patios, and siding.
 - e. Cedar--which is light and easy to split--is used for fence posts, sills, and shingles.
 - f. Spruce--which is light, straight, strong, and resonant--is used for aviation and musical instruments.
2. Hardwood comes from broad-leaf trees that lose their leaves each fall season, called deciduous trees.
 - a. Oak--which is tough, strong and open-grained--is used for floors, interior finish, barrels, and furniture.
 - b. Walnut--which has a beautiful, brown, open grain--is used for fine furniture.
 - c. Maple--which is a very durable and light-grained--is used for floors, interior finish, furniture, and guitar necks.
 - d. Mahogany--which is reddish in color--is used for fine furniture.
 - e. Birch is used for surface veneer on cabinets and doors.

B. Log Cutting Methods and Lumber Finishes

1. Cutting Methods

- a. Slash sawing cuts a log so that the annular rings form an angle of less than 45 degrees with the surface of the lumber.
 - 1) Softwood lumber cut in this fashion is referred to as flat-grained.
 - 2) Hardwood lumber cut in this fashion is referred to as plain-sawed.

130H-3

b. Quarter sawing cuts a log so that the annular rings form an angle of more than 45 degrees with the surface of the lumber.

1) Softwood lumber cut in this fashion is referred too as edge-grained.

2) Hardwood lumber cut in this fashion is referred too as quarter-sawed.

2. Finishes

a. Rough lumber comes directly from the sawmill unplaned and varying in dimensions from piece to piece.

b. S2S is lumber surfaced on two sides allowing all pieces to have the same thickness, but varying widths.

c. S4S is lumber surfaced on four sides allowing exact dimension from piece to piece. The actual sizes are 1/2 inch less than the nominal sizes; for example, the actual size of a 2 x 4 is only 1 1/2" x 3 1/2."

C. Kinds of Lumber and Wood Panels

1. Wood cut into uniform thickness, width, and length is called lumber.

a. Boards are lumber used for flooring, sheathing, paneling, and trim.

b. Dimension lumber is used for sills, plates, studs, rafters, and other framing members.

c. Timbers are lumber used for posts, beams, and heavy stringers.

2. Wood panels (usually 4' x 8') are made through various methods.

a. Plywood consists of thin layers of wood glued together with the wood grain turned at right angles in each successive layer.

b. Composite board consists of a core of wood fibers bonded on either side with veneer.

c. Hardboard consists of refined wood fibers pressed together to form a hard, dense material (55 - 75 lb. per cu. ft.).

d. Particle board consists of wood flakes, chips, and shavings bonded together with resins or adhesives to form a less dense material (42,45, or 47 per cu. ft.).

e. Waferboard consists of high quality flakes of wood (about 1 1/2 inch square) bonded together under heat and pressure with the waterproof adhesive, phenolic resin.

- f. Oriented strand board is similar to waffleboard in appearance, but consists of wood fibers bonded together in successive layers arranged at right angles to one another.

D. Grades

1. The Basis of Lumber Grades

- a. Lumber grades are based on the appearance and soundness of the wood.
- b. The fewer and less obvious the defects, the more the lumber costs.
 - 1) A lumber defect is an irregularity in or on the wood that reduces its strength, durability, or usefulness.
 - 2) A lumber blemish is a defect that impairs only the wood's appearance.

c. The common lumber defects include the following:

- 1) Knots are embedded branches or limbs in the lumber.
- 2) Holes can be caused by mishandling or insects and worms.
- 3) Splits and checks are separations of the wood fibers along the grain and across annular growth rings.
- 4) Shakes are separations of wood fibers along the grain and between annular growth rings.
- 5) Pitch pockets are cavities that contain or have contained liquid or solid pitch.
- 6) Honeycombing is the separation of wood fibers inside the lumber, which may not be visible on the surface.
- 7) Wane is the presence of bark or the absence of wood along a board's edge.
- 8) Decay is the disintegration of wood fibers caused by fungi.
- 9) Blue stain is the discoloration caused by any of various fungi (as of the genera *Ceratostomella*, *Penicillium*, or *Fusarium*)
- 10) Warp is any variation from a plane surface, including cups, bows, crooks, and twists.

2. Basic Lumber Grades

- a. Select refers to lumber of good appearance and finishing qualities.
 - 1) Grades A and B are suitable for natural finishes.
 - 2) Grades C and D are suitable for paint finishes.
- b. Common refers to lumber containing defects and blemishes.
 - 1) Common no. 1, 2, and 3 are suitable for use without waste.
 - 2) Common no. 4 and 5 are suitable for use permitting waste.

3. Plywood Grades

- a. A grade lettering system is used to indicate the quality of the veneer used on the face and back of the panel.
 - 1) N is a veneer with a smooth surface suitable for natural finishes.
 - 2) A is a veneer with a smooth surface suitable for painting.
 - 3) B is a veneer with a solid surface.
 - 4) C Plugged is an improved C veneer with splits limited to 1/8 inch width, and knotholes and bore holes limited to 1/4 x 1/2 inch.
 - 5) C is a veneer with tight knots to 1 1/2 inch.
 - 6) D is a veneer with knots and knotholes to 2 1/2 inch width across the grain which is limited to interior, Exposure 1 and 2 panels.
 - 7) G2S means the veneer is good on two sides.
 - 8) G1S means the veneer is good on only one side.
- b. Mills which are members of the American Plywood Association (APA) indicate the panel's intended use or performance rating with an APA trademark stamp, which includes the following information:
 - 1) Panel grade indicates its use, such as sheathing.
 - 2) Span rating is indicated by a pair of numbers separated by a slash, such as 32/16.

130H-6

- a) The 32 indicates the maximum recommended span in inches when used as roof sheathing.
 - b) The 16 indicates the maximum recommended span in inches when used as subflooring.
- 3) Thickness in inches (common sizes being 1/4, 3/8, 1/2, 5/8, and 3/4).
- 4) Exposure durability classification is indicated by three names:
- a) Exterior is bonded with a 100% waterproof glue allowing it to be used outdoors and continually exposed to moisture.
 - b) Exposure 1 is interior plywood that can be exposed to moisture for extended periods.
 - c) Exposure 2 is interior plywood that can withstand some leakage or high humidity for short periods.

E. Factors to Consider When Selecting Lumber

1. Quality construction does not require that all the lumber be of the best grade.
2. Several grades of lumber may be appropriate in a single structure.
3. Good economical construction requires the proper use of the lowest grade lumber suitable for the purpose.

ACTIVITY:

1. Practice identifying different kinds of wood.
2. Practice identifying different kinds of lumber and wood panels.
3. Practice identifying wood defects.
4. Practice identifying lumber and plywood grades.
5. Select lumber and wood panels for an ongoing project, such as a toolbox or sawhorse.

MEASURING AND MARKING WOOD

A. Measuring and Marking Vocabulary

1. Straight - an adjective describing a line that is the shortest distance between two points
2. Square - an adjective describing lines, surfaces, or planes positioned at right angles (90 degrees) to one another

130H-7

3. Perpendicular - an adjective describing a line, surface, or plane that is positioned at a right angle to another line, surface, or plane
4. Level - an adjective describing a line, surface, or plane lying parallel to the plane of the horizon (axis or the earth) having the same height everywhere
5. Plumb - an adjective describing a line, surface, or plane that is exactly vertical or true
6. Flush - an adjective describing the positioning of two or more objects so that their edges, surfaces, or ends are even, level, or on the same plane
7. Bevel - a sloping edge (less than 90 degrees)
8. Miter - a term usually referring to a 45 degree angle
9. Working edge or surface - the main edge or surface from which the other surfaces are measured or squared

A. Using a Tape Measure to Measure and Mark Wood:

1. Measuring the Distance between Two Points:

a. Place the end of the tape precisely on the first point.

- 1) The hook on the end of most tapes slides a distance equal to the thickness of the hook in order to provide accurate measurements whether it is hooked onto the end or edge of a board or pushed against a surface.
- 2) If the hook is damaged or missing, start the measurement at the one inch graduation line and subtract one inch from tape reading.

b. Extend the tape to the second point.

- 1) Make sure all slack is taken out of the tape between the two points, or the resulting reading will be too long.
- 2) Make sure the tape is flush with the edge of the board being measured. If the tape angles even slightly across the board, the reading will be too long.

c. Read the tape at the graduation line on or nearest the second point (See section 130C, Measuring).

- 1) Long tapes are slightly arched across their width so they will remain fairly rigid while being extended; therefore, make sure the edge of the tape touches the wood if a very exact reading is required.

130H-8

- 2) If measuring the distance between two inside surfaces, push the tape hook against one side and the tape case against the other, then read the graduation line nearest the tape case and add the length of the case to the reading.

2. Marking Wood for Cutting

- a. To lay off a measurement on a board, attach the tape hook to the end of the board or place the one inch graduation precisely at the beginning mark and mark the board with a sharpened pencil at the desired graduation line on the tape.
 - 1) When laying off several measurements in a straight line along a board, do not raise or move the tape until all the measurements are marked.
 - 2) If the tape is raised and moved for each measurement, the possibility of errors is greatly increased.
- b. To quickly and easily locate the middle of a board when the total width is a difficult-to-divide number (for example, $2 \frac{5}{8}$ " or $11 \frac{13}{16}$ "), lay a measuring tape across the board at any angle necessary to make full inch marks on the tape line up with both edges of the board. Then mark on the board the halfway point along the tape that is between the two edges of the board.
 - 1) Do this at both ends of the board, then connect the two marks with the help of a straight edge or gauge.
 - 2) This procedure can also be used to divide a board into three or more equal widths.

B. Using Squares to Measure and Mark Wood

1. Using a Carpenter's Square (Framing Square)

- a. To mark boards to be sawed square (90 degrees to the working edge), use the following steps:
 - 1) Measure and mark the desired length of the board.
 - 2) Place the body of the square firmly against the working edge of the board.
 - 3) Move the square until the inside edge of the tongue is against the length mark.

130H-9

4) Holding a sharp pencil against the edge of the tongue, draw a thin line through the length mark and across the board.

b. To mark boards to be sawed at the same angle, use the following steps:

- 1) Position the square with the outside edge of the tongue along the angle cut in the end of the board to be duplicated.
- 2) Record the readings where both the tongue and the body meet the edge of the board.
- 3) Position the square on the board to be marked with so that the same two readings meet the edge of the board.
- 4) Holding a sharp pencil against the edge of the tongue, draw a thin line across the board, which will be the same angle as the original board.

2. Using a Combination Square

- a. As a ruler, it can be used to measure distances up to 12 inches.
- b. As a straight edge, it can be used as a guide for marking straight lines between points.
- c. As a try square, it can be used for both marking and checking angles on wood.

1) It can be used as a guide to draw both 90 degree and 45 degree lines across the face, edge, or ends of boards.

- a) To mark a 90 degree angle, extend the blade from the 90 degree shoulder, and place that shoulder firmly against the working edge from which the other surfaces are to be measured or squared.
- b) To mark a 45 degree angle, extend the blade from the 45 degree shoulder, and place the shoulder firmly against the working edge.

2) It can be used to check the exactness of a right angle or miter angle cut by placing the appropriate shoulder firmly against the working edge and attempting to line up the blade with the cut.

d. As a marking gauge, it can be used for marking lines parallel to the edge of a board.

130H-10

- 1) Extend the blade the desired distance from the 90 degree shoulder.
- 2) Move the 90 degree shoulder along the edge while marking the wood with a pencil held against the end of the blade.

- e. As a depth gauge, it can be used to measure the depth of a dado or rabbet.
- f. As a level, it can be used to level or plumb an object.

3. Using the Sliding T-bevel Square

- a. It can be used to mark angles or bevels on wood.

- 1) The adjustable blade can be set to the desired angle by several methods.
 - a) Place the handle against the working edge of the board and adjust the blade so that it fits the angle marked or cut across the board.
 - b) Or, the angle can be set using a protractor if the degrees are known.
- 2) The bevel square set to the desired angle is then used as other squares are to mark off the angle.

- b. It can be used to check angles cut in wood.

- 1) Place the handle against the working edge of the board and adjust the blade so that it fits the angle cut across the board.
- 2) Place the handle against the base of a protractor and note the reading where the adjusted blade meets the arch.

C. Using Chalk Lines, Plumb Lines, and Levels to Mark and Check Wood

1. Using a Chalk Line to Mark Wood

- a. Stretch a strong cotton or nylon string coated with colored chalk between the two points meant to be joined by a straight line.
- b. Lift the line midway between the two points and allow it to snap back into place.
- c. Remove the chalk line and a straight mark will be left.

130H-11

2. Using a Plumb Line to Mark Wood

a. It can be used to locate a point directly below another.

- 1) Tie the plumb line to a nail in the point desired and allow the plumb bob to come to rest.
- 2) Mark the wood directly below the point of the plumb bob.

b. It can be used with a carpenter's square to mark a level line.

- 1) Suspend the plumb line and allow the plumb to come to rest.
- 2) Align the body of the square with the plumb line.
- 3) Mark the level line with a sharp pencil along the edge of the tongue of the square.

3. Using a Level to Mark Wood

a. To make a level mark on a vertical surface, position the level against the surface so that the bubble in the middle tube is centered, then mark a line with a sharp pencil along the edge of the level.

b. To make a plumb mark on a vertical surface, position the level against the surface so that the bubble in the tube located near the end of the level is centered, then mark a line with a sharp pencil along the edge of the level.

ACTIVITY:

1. Practice using a measuring tape to measure and mark wood for cutting.
2. Practice using squares to measure and mark wood for cutting.
3. Practice using a chalk line, plumb line, and level to mark wood for cutting.
4. Measure and mark wood to be cut for an ongoing wood project, such as a toolbox or sawhorse.

WOODWORKING HAND TOOLS

SAFETY IN CARPENTRY WORK

Observe the following general safety practices in doing all carpentry work.

1. Wear industrial-quality safety glasses. When the work has the possibility for eye injury, be sure to wear safety glasses. Safety glasses should have the Z87.1 log on them to assure they are industrial quality.
2. Wear safety-toed shoes. When handling heavy carpentry materials, wear safety-toed shoes to protect your feet and toes.
3. When handling carpentry materials, wear a hard flat hat or a bump cap to protect the head.
4. When handling rough carpentry materials, wear gloves.
5. When painting, insulating, or working in dusty conditions, always wear an appropriate-type respirator.
6. Work clothing should not be loose, baggy, or highly flammable. The big danger is getting loose clothing caught in power machinery. Synthetic clothing is subject to low flashpoints, which may result in severe burns. When working on carpentry jobs, avoid wearing such clothing.
7. Use correct hand tools for each job. Hold each tool correctly and use it properly.
8. Lift and carry heavy objects correctly. When lifting a heavy object, stand close to the object, bend your legs to pick up the object, then lift with your legs, not your back.
9. Work defensively to avoid falls and falling objects.
10. Practice good fire safety where fire hazards exist. Use the appropriate type of extinguisher if a fire should occur: Type A extinguishes wood and paper fires; Type B extinguishes gasoline, oils, and paint fires; and Type C extinguishes electrical fires.
11. Remove protruding nails from unused lumber. Prevent puncture injuries by removing nail hazards.

SAFETY IN HAND AND PORTABLE POWER TOOL WOODWORKING

SAFETY PRACTICES FOR USING HAND TOOLS

The following are general safety practices for using hand tools.

1. Secure the work. Always use a clamp, a vise, or some means to hold the work. Securing the work prevents it from slipping and frees both hands to hold tools.
2. Store tools properly. When tools are not in use, store them safely. Store all sharp-edged cutting tools with the sharp edges down.

3. Keep tools clean. Keep all hand woodworking tools clean and free of oil and grease so they will not slip when in use.
4. Inspect tools before using. Tools that damaged or have broken handles should be marked unsafe. Do not use them until they have been repaired.
5. Use the correct tool for the job. Use each hand woodworking tool only for the job for which it was designed. Forcing a small tool to do the job of a large one may result in injury or tool damage.
6. Grip tools firmly. Hold hand woodworking tools--especially the hammer and wrenching bar--securely so that they do not slip and hit someone. Hold tools such as the plane with both hands. Do not wear gloves-they are bulky and make gripping tools difficult.
7. Use the correct hammer. Never use a machinist's hammer in place of a carpenter's hammer. Do not strike a hardened steel surface, such as an anvil, with a steel hammer because a small piece of steel may break off and injure someone.
8. Avoid hammers with damaged handles. Do not use hammers with broken or split handles. Make sure the handle fits tightly in the hammer head.
9. Stand in a safe location. When using a hammer or a hatchet, do not let anyone stand directly in line with the tool's path of movement.
10. Hold nails tightly. When starting a nail, hold it tightly so that it will not fly loose and hit someone.
11. Remove nails. Before using any cutting tool--including saws, wood chisels, planes, and drills--remove nails or other objects that might destroy the tool's cutting edge.
12. Keep cutting tools sharp. Sharp tools insure the best results and the safest operation.
13. Cut away from the body. When using tools with sharp edges, always cut away from the body.
14. Use the correct screw driver. Be sure the screw-driver bit fits properly in the screw slot to prevent it from slipping and causing injury.
15. Avoid checking circuits with screw drivers. Never use a screw driver to see if electrical circuits are hot.
16. Be careful when gluing. Read labels on containers to check for harmful fumes and highly flammable glues.

SAFETY PRACTICES FOR USING PORTABLE POWER TOOLS

The following are general safety practices for using portable power tools.

1. Obtain the instructor's permission. Obtain permission before using any portable power tool.
2. Protect your eyes and face. When using portable power tools, wear industrial-quality safety glasses or a safety shield.
3. Wear proper clothing. Do not wear loose-fitting clothing or jewelry that can get caught in moving parts. Do not roll up long sleeves.

4. Protect your hair and scalp. Pull back long hair in a band or a cap to keep it from getting caught in tools.
5. Know the tool. Read the operator's manual to learn the tool's applications and limitations as well as its potential hazards.
6. Use a respirator. Use a filter-type respirator in dusty conditions.
7. Avoid electrical shock. Be sure each tool has a three-blade grounding-type plug or is double insulated. Avoid using power tools in damp or wet places without standing on a dry board. Wear rubber gloves and boots for outdoor jobs.
8. Keep the work area clean. Keep the floor free of scraps and oil. Cluttered work areas and benches invite accidents.
9. Work only at operating speed. Do not use a power tool before it has reached operating speed or while it is coming to a stop. Never force a tool by applying too much pressure.
10. Never stop moving parts abruptly. Once a tool has been turned off, allow it to coast to a stop. Never force the tool into stock to stop it. Be sure the tool has come to a complete stop before laying it down.
11. Unplug tools properly. Unplug each tool from the power source after use and when you service or change accessories in a safe place when not in use.
12. Store unused accessories. Store tools and accessories in a safe place when not in use.
13. Use both hands. Use both hands to hold and guide saws and drills.
14. Stand in a safe location. To avoid being hit if the tool kicks back, do not stand directly behind the equipment.

* Reprinted by permission of Interstate Publishers, Inc., from MODERN AGRICULTURAL MECHANICS, 2nd ed., by Stanley R. Burke and T. J. Wakeman. Copyright 1992 by Interstate Publishers, Inc.

A. Using Hand Saws

1. Crosscut Saw

- a. A crosscut saw is used to cut across the grain of a board and can be identified by its teeth, which are filed to a point.
- b. To cut across the grain of a board, perform the following steps:
 - 1) If right-handed, grasp the handle with the right hand with the index finger extended along the side of the handle, which helps to guide the saw more accurately.
 - 2) Position your body to the work so that your shoulders form an angle of about 45 to 60 degrees to the sawing direction, and your saw, right arm, elbow, shoulder, and eye are all in the same vertical plane.
 - 3) Place the left knee on the board to hold it firmly on the sawhorses.
 - 4) Grasp the far edge of the board with the left hand and use the thumbnail against the saw blade as a guide to start the cut.
 - 5) Place the heel of the saw beside the line on the waste side and start the cut by making several backstrokes, lifting the saw on the forward strokes.
 - 6) After the cut is started, push the saw forward while applying light, downward pressure at a 45 degree angle to the surface of the board.
 - 7) Complete the cut using long, easy strokes without pressure on the return strokes, since the saw is designed to cut on the forward stroke only.
 - 8) If the saw tends to go off course, twist the handle slightly while sawing to make it come back to the line gradually.
 - 9) If the saw tends to get off square, bend the blade slightly while sawing to straighten it.
 - 10) To finish the cut without splintering the board, complete the last few strokes slowing and without pressure on the saw while holding up the other end of the board.

2. Rip Saw

- a. A rip saw is used to cut along the length of the board (with the grain) and can be identified by its teeth, which are filed to a knifelike edge and number fewer per inch than a crosscut saw.

130H-16

- b. To cut a board along its length with a rip saw, perform the above steps, but operate the saw at 60 degrees to the surface of the board instead of 45 degrees.

3. Back Saw

- a. A back saw is used with or without a miter box to make very accurate angle cuts in narrow boards and can be identified by its rigid metal back and very fine teeth.
- b. To make an accurate cross cut, perform the same steps as used with a crosscut saw or use a wooden miter box or adjustable miter box to help hold the board and guide the saw when cutting angles.

4. Coping Saw

- a. A coping saw is used to cut large holes and irregular, curved cuts in thin wood, and can be identified by its thin, narrow, removable blade supported by a spring steel frame.
- b. To cut large holes or other shapes in thin wood panels or boards, perform the following steps:
 - 1) Drill a starter hole next to the line through the waste wood.
 - 2) Remove the blade from the frame; insert it into the hole, and reattach it to the frame so that it cuts on the pull stroke, and is less apt to kink or break.
 - 3) Secure the wood in a vise or hold it level on a work bench allowing it to project over the bench top.
 - 4) Cut out the shape with long, steady, moderately slow strokes with the cut being made on the pull or downstroke depending on the position of the wood.
 - 5) Cut as far as the frame will allow, then turn the blade a quarter turn in the frame and continue to saw until the frame stops the cut again.

5. Compass and Keyhole Saw

- a. A compass saw and a keyhole saw are used to cut wood start in from a hole in the wood, and can be identified by their narrow, tapered blade and pistol grip handle.
- b. To make straight and curved cuts in wood panels and boards with these saws, perform the following steps:

130H-17

- 1) Bore a 1-inch starter hole next to the line in the waste wood with an auger bit.
- 2) Secure the wood in a vise and insert the blade in the starter hole.
- 3) Cut along the line with the cutting edge perpendicular to the wood surface, not at angles as with crosscut and ripsaws.
- 4) When cutting sharp curves, use short strokes with the narrow end of the blade.
- 5) Since these saws do not leave smooth surfaces when cutting sharp curves, do not try to cut exactly to the line, but leave about 1/16 inch to be removed with a file or spokeshave.

B. Using Boring and Drilling Tools

1. Bit Brace

- a. A bit brace is a large crank-type handle used to turn auger bits, expansive bits, twist drills, spade bits, forstner bits, countersinks, and reamers for boring holes (1/4 to 2 inches) in wood.
- b. To use a bit brace to bore wood with an auger bit, perform the following steps:
 - 1) To start the auger bit on the mark or center hole, guide the bit point with one hand, knuckles down against the wood, and exert slight pressure on the head of the brace with the other hand.
 - 2) While maintaining pressure on the brace head, turn the brace handle with the free hand keeping the bit perpendicular to the surface.
 - 3) Check to make certain the auger bit is boring square by sighting from two directions or by using a square against the bit and the surface.
 - 4) Lean on the top of the brace slightly to change the direction of the boring if it is not square.
 - 5) To prevent splintering when boring entirely through a board, stop when the point of the bit starts to poke through, then turn the board over and finish the bore from that side.

2. Hand Drill

- a. A hand drill is a tool with gears that turn a bit much faster than its handle turns, but with reduced turning power allowing it to drill holes only up to 1/4 inch diameter in wood.
- b. To drill holes in wood with a hand drill, perform the following steps:
 - 1) Place the bit on the mark perpendicular to the surface; push with a light, even pressure against the handle, and turn the crank with a steady, moderate speed.
 - 2) A wooden dowel can be placed on the bit as a depth gauge if holes of uniform depth are required.
 - 3) When drilling entirely through a board, release some of the pressure on the bit as it starts to break through to prevent splintering.

3. Push Drill

- a. A push drill, or automatic drill, is used for rapidly drilling holes (up to 3/16 inch) for installing screws, and is identified by its spring-loaded, spiral-shaped shaft that turns clockwise when the handle is pushed down.
- b. To drill screw starter holes in wood with a push drill, perform the following steps:
 - 1) Place the bit on the mark perpendicular to the surface of the wood.
 - 2) Push on the handle with one hand to impart a forward rotary motion to the bit.
 - 3) Release the pressure on the handle allowing it to extend, imparting a backward rotary motion to the drill bit.
 - 4) Pull the bit out of the hole when the hole is the desired depth.

C. Using Shaping Tools

1. Plane

- a. A plane is used to shave wood in order to obtain a smooth surface, and comes in different lengths.
- b. To adjust a plane, perform the following steps:

130H-19

- 1) Turn the plane upside down and sight along the bottom of the plane from front to rear to verify that the blade is projecting through evenly and no more than 1/32 inch.
- 2) If adjustments are required, turn the depth-adjusting nut until the blade projects about 1/32 inch, and move the lateral adjusting lever until the blade extends through the throat evenly at both corners.
- 3) Make a trial cut and readjust the plane, if necessary, until it cuts smoothly and produces a thin, semi-transparent curl of wood with each stroke.

c. To plane a wood surface, perform the following steps:

- 1) Secure the board on the bench and stand to the left of the work with feet apart and with the left foot slightly forward.
- 2) Hold the plane with the left hand, palm down, on the knob and the right hand grasping the handle.
- 3) Plane with the grain of the wood from one end of the board to the other end without stopping.
- 4) At the beginning of each stroke, press down hard on the knob, and as you push the plane forward gradually shift more weight to the left foot.
- 5) Toward the end of each stroke, reduce the pressure on the knob and press down hard on the handle.
- 6) Always lay the plane on its side when the job is over in order to keep the cutting edge from being dulled.
- 7) Check the board with a straight edge.

2. Chisel

- a. A chisel is used to shave wood in recessed areas, and is available in widths ranging from 1/8 to 2 inches.
- b. To chisel wood with the grain, perform the following steps:

- 1) If possible, secure the wood in a vise in order to leave both hands free to use the chisel.
- 2) Guide the chisel with the left hand, and push the handle forward with the right hand.
- 3) Always keep both hands behind the cutting edge and push the chisel away from you.
- 4) To make the chisel blade cut easier, give it an oblique cutting edge by holding the handle slightly to one side, or by moving the handle from side to side.

130H-20

5) Push the chisel with the bevel down for rough cuts and with the bevel up for finishing cuts.

c. To chisel wood across the grain, perform the following steps:

- 1) Push the chisel with the bevel up, except on wide boards where the chisel cannot reach the center.
- 2) Raise the handle just enough to make the blade cut.
- 3) To avoid splintering the edges, cut across the board partway from one side and partway from the other side.
- 4) A mallet may be used to drive the chisel for heavy chiseling or roughing cuts.

3. File

a. A file is used to smooth edges and shape wood to odd shapes, and may be flat, half-round, round, square, or triangular.

b. To dress down and smooth rough cuts on boards, perform the following steps:

- 1) A file with a sharp tang should never be used without a handle. Install a handle if necessary.
- 2) Hold the file handle in the right hand and guide the file with the left hand.
- 3) Push the file lengthwise along the board, never across the edge of the board.
- 4) Since the file teeth cut only when pushed forward, apply pressure on the forward stroke only.
- 5) Lift the file off the wood on the return stroke.
- 6) If the file teeth become clogged with sawdust, clean them with a wire brush or file card.

ACTIVITY:

1. Practice cutting, drilling, and shaping wood with ten different hand tools.
2. Cut, drill, and shape wood to be used in an ongoing wood project, such as a toolbox or sawhorse.

WOODWORKING POWER TOOLS

SAFETY IN POWER WOODWORKING

Safety Practices for Using Stationary Power Tools

The following are general safety practices for using all stationary power tools.

1. Obtain the instructor's permission. Obtain instructor's permission before you use any stationary power tool.
2. Wear proper clothing. Do not wear loose-fitting clothing or jewelry that can get caught in moving parts. Do not wear gloves. Do not roll up long sleeves.
3. Protect your scalp and hair. Pull back long hair in a band or a cap to keep it from getting caught in moving machine parts.
4. Keep guards in place. Guards cannot protect you if they are not in place and in proper working order.
5. Avoid shock. Be sure that equipment is properly grounded. Do not use power tools in a damp or wet place without standing on a rubber mat.
6. Keep the work area clean. Keep the floor free of sawdust, grease, oil, and scraps. Cluttered work areas and benches invite accidents.
7. Unplug the machine. The electrical service to each machine must be disconnected when it is not in use, while it is being serviced, and when the accessories are being changed.
8. Work only at operating speed. Do not use a power tool before it has reached operating speed or while it is coasting to a stop.

TABLE SAWS

Safety Practices for Using Table Saws

Before studying the specific safety practices for using table saws, review the general safety practices for using stationary power tools.

1. Do not roll up long sleeves. Do not wear loose fitting clothing such as coats and ties.
2. When operating the table saw, do not wear gloves. Gloves are bulky and may easily be caught on parts of the table saw, thus creating an additional safety hazard.
3. Remove rings, bracelets, and other loose-fitting jewelry which have the potential of getting caught on the saw or materials.
4. Check the saw blade periodically for broken teeth and cracks.
5. When operating the table saw, stand to one side of the saw blade.
6. Make certain the blade guard, splitter, and anti-kickback device are used for all possible sawing operations.

7. Never reach over the saw blade to remove or hold down a piece of stock.
8. Avoid awkward work positions that may result in slips and contact with the saw blade.
9. Never raise the saw blade more than 1/4" above the material being cut. Lower the blade below the table top before you leave the work area.
10. Do not attempt to rip round or irregularly shaped stock on the table saw.

* Reprinted by permission of Interstate Publishers, Inc., from MODERN AGRICULTURAL MECHANICS, 2nd ed., by Stanley R. Burke and T. J. Wakeman. Copyright 1992 by Interstate Publishers, Inc.

A. Portable Circular Saw

1. Purpose and Parts Identification:

- a. The portable circular saw is an electric handsaw with a round blade used for making freehand cross, rip, miter, and bevel cuts in lumber and in assembled woodwork.
- b. Its parts and their purposes are as follows:

- 1) The handle allows the operator to hold onto the saw.
- 2) The safety switch controls the power to the saw's motor.
- 3) The motor converts electrical power into rotary motion.
- 4) The power cord supplies electrical power to the motor.
- 5) The shoe or base rests on the wood being cut.
- 6) The upper guard protects the operator's body from the top of the saw blade.
- 7) The telescoping guard protects the operator's fingers from the bottom of the blade.
- 8) The depth adjustment controls blade depth below the shoe.
- 9) The tilt adjustment tilts the shoe to control blade angle.
- 10) The arbor shaft supports and rotates the blade.
- 11) The circular blade cuts the wood.

- a) Rough cut combination
- b) Crosscut
- c) Rip
- d) Standard combination or miter

2. Safe Adjustment and Operation Procedures for Portable Circular Saw

130H-23

- a. Always plug the saw's cord into a grounded outlet, and keep the cord clear of the blade.
- b. Adjust the depth of the blade so that it extends about 1/8 inch (approximately the depth of one tooth) beyond the thickness of the wood being cut.
- c. Check both the depth and angle adjustments to insure that they are tight.
- d. Before turning on the switch, rest the saw base firmly on the wood with the blade clear to turn freely.
- e. While cutting the wood, stand to one side of the cutting line, and keep the free hand away from the cutting direction and from underneath the wood.
- f. If the portable circular saw has two handles, keep both hands on them while cutting the wood.
- g. Always make sure the wood is well-supported so that the kerf does not close and bind the blade while cutting.
- h. Provide support for thin wood near the cutting line, and secure small pieces to a benchtop or sawhorse with clamps.
- i. Be alert while cutting in order to avoid cutting into sawhorses or other supports.
- j. Never use a blade that is dull or out of condition.
- k. Always stop and unplug the saw before changing blades or making adjustments.

A. Table Saw (Stationary Circular Saw)

1. Purpose and Parts Identification:

- a. The table saw is a stationary circular saw (round blade) mounted in a table, which is used primarily for rip cutting wood. It can also do ripping, beveling, mitering, dadoing, etc.
- b. Its parts and their purposes are as follows:
 - 1) The body houses the table saw parts.
 - 2) The safety switch controls the electrical power to the motor.
 - 3) The table provides the work area.
 - 4) The circular blade cuts the wood.
 - 5) The blade guard protects fingers from the blade.
 - 6) The saw height wheel is the front wheel that adjusts the height of the blade above the table.
 - 7) The arbor tilt wheel is the side wheel that adjusts the blade tilt angle.

- 8) The ripping fence guides the wood when making rip cuts.
- 9) The miter gauge guides the wood when making crosscuts.

2. Safe Adjustment and Operation Procedures for Table Saw

- a. Always obtain permission from the instructor before operating the saw.
- b. Use only saw blades that are sharp and properly set.
- c. During setup, make sure the blade is tightly fastened to the arbor with its teeth pointing towards the operator and able to spin freely.
- d. Make sure the saw guard, splitter guard, and kickback teeth are in place and use them whenever possible.
- e. Adjust the blade so that it extends 1/8 to 1/4 inch (approximately the length of one tooth) above the wood to be cut.
- f. Always hold the wood against the ripping fence or miter gauge when cutting, never freehanded.
- g. Before using the ripping fence, make sure that it is locked into position at the proper distance from the blade.
- h. Never use the ripping fence as a guide for crosscutting, or kickback may occur.
- i. Before using the miter gauge, make sure it slides freely down the entire length of the slot.
- j. When using the miter gauge, hold the wood firmly against it and down on the table.
- k. Stand to one side of the spinning saw blade to avoid kickback, and never reach over it.
- l. Tail off when cutting long or bulky material, but do not push or pull the wood through.
- m. Always keep a 4-inch margin between fingers and the blade, and use a push stick when ripping narrow pieces.
- n. Always push the wood clear of the blade before releasing it.
- o. Never try to cut warped or rough lumber on the saw.
- p. Stop and disconnect the saw before making adjustments.
- q. When the cut is complete, turn off the switch and remain by the saw until the blade has stopped.

B. Radial Arm Saw

1. Purpose and Parts Identification

130H-25

- a. The radial arm saw is a motor and circular blade supported by an overhead arm that is primarily used for crosscutting long lumber on a stationary table. It differs from the table saw in that the wood is usually held stationary while the blade is moved. Like the table saw, it can also be used for mitering, beveling, dadoing, and ripping but it is not as accurate as the table saw.
- b. Its parts and their purposes are as follows:
 - 1) The overarm supports the motor and blade over the table and allows them to cut miters and move back and forth.
 - 2) The safety switch controls the electrical power to the motor.
 - 3) The miter scale indicates the miter angle of the overarm.
 - 4) The elevating crank raises and lowers the blade.
 - 5) The column supports the overarm and saw.
 - 6) The yoke supports the motor and blade over the table and allows them to turn parallel to the fence to rip wood.
 - 7) The handle pulls the blade into the wood to make the cut.
 - 8) The upper guard protects the operator's body from the spinning blade.
 - 9) The lower guard protects fingers from the blade.
 - 10) The antikickback fingers prevent the blade from kicking back pieces of wood.
 - 11) The fence holds the wood in place for cutting.
 - 12) The table provides the work area.

2. Safe Adjustment and Operation Procedures for a Radial Arm Saw

- a. Obtain permission from your instructor before using the radial arm saw.
- b. Use only saw blades that are sharp and properly set.
- c. During setup, make sure the blade is tightly fastened to the shaft with its bottom teeth pointing away from the operator and able to spin freely.
- d. Make sure the guards and kickback fingers are in place and use them whenever possible.
- e. Adjust the blade so it penetrates 1/16 inch below the surface of the table.
- f. Make sure the adjustment knobs and levers are tight and the carriage lock released.
- g. Hold the wood to be cut firmly on the table and against the fence, making sure the ends of long boards are supported even with the table.

130H-26

- h. Keep a 6-inch margin of safety between your hand and the blade, and keep your arms parallel to the line of cut while holding the wood.
- i. Before starting the motor, make sure the blade is clear of the wood, and before cutting allow it to accelerate to full speed.
- j. Never force the saw or cut too fast, because this may bind the blade.
- k. Since the direction of the teeth pull the blade into the cut, it may be necessary to apply back pressure against the handle to control the speed of the cut.
- l. When crosscutting, always pull the blade towards you and return the saw to the rear of the table after completing the cut.
- m. When ripping, always feed the wood into the blade from the side where the bottom teeth are pointing towards you.
- n. Stop and disconnect the saw before making adjustments.
- o. After finishing a cut, do not leave the saw until the blade has completely stopped.

ACTIVITY:

1. Take a safety test for each power tool.
2. Change blades and adjust the power tools.
3. Operate the power tools correctly and safely to cut lumber and wood panels for an ongoing wood project, such as a toolbox or sawhorse.

FASTENING WOOD JOINTS

A. Basic Wood Joints

1. Butt Joints

- a. Butt joints are formed by joining two boards end to end, or edge to edge (in line or at a right angle).
- b. Butt joints can be reinforced by fastening thin wood or metal gussets to the corners or across the flat surfaces where the boards join.

2. Lap Joints

- a. Lap joints, which are stronger than butt joints, are formed by joining two boards face to face.
- b. Lap joints can be strengthened by offsetting the boards so they fit into each other.

3. Dado Joints

- a. A dado is a rectangular groove cut into a board.
- b. Dado joints are formed by inserting the end or edge of another board into this groove.

4. Rabbet Joints

- a. A rabbet is a rectangular groove cut in the end or edge of a board.
- b. Rabbet joints are formed by inserting the end or edge of another board into this groove.

5. Miter Joints

- a. Miter joints formed by cutting the ends of two boards at a 45 degree angle and joining them together to form a 90 degree angle.
- b. Miter joints are usually (depending on the grain direction at the joint) stronger than butt joints because they provide more surface contact at the joint.

B. Fastening Wood Joints with Nails

1. Hammers

- a. Two types of hammers are commonly used.
 - 1) The curved claw hammer is the most common; it is designed for pulling nails.
 - 2) The ripping claw hammer has a straight claw which can be driven like a chisel between two fastened boards to pry them apart.
- b. In order the claw hammer's size is indicated by the weight of its head, which ranges from 7 oz. to 20 oz.

- 1) A general purpose claw hammer usually comes in the 13 oz. size.
- 2) Framing hammers used by carpenters usually come in either the 16 oz. or 20 oz. size.

2. Driving Nails

a. In order to drive a nail, the following steps should be performed:

- 1) To start the nail, hold it between the thumb and index finger and place its point on the desired spot.
- 2) To avoid smashing the fingers if the hammer accidentally hits them, place them high on the nail to allow them to be knocked free rather than against the wood.
- 3) To prevent splitting a dry or thin board when driving the nail, use a smaller nail, or blunt the tip of a chisel-shaped nail; if using small nails, cut them off square.
- 4) Grasp the hammer near the end of the handle with the free hand, and keeping your eyes focused on the nail head, tap the nail one or two times with the hammer until it stands on its own.
- 5) Use the weight of the hammer to drive the nail, using mostly wrist action for light driving; combine wrist action that with elbow action for heavier driving; combine both wrist and elbow action with shoulder action for very heavy driving.
- 6) Continue to drive the nail until its head is flush with the surface and the two pieces of wood are tightly fastened; careful not to leave a hammer mark with the final blow.

b. The type of nailing is determined by the kind of joint and by the wood thickness.

- 1) In flat nailing, nails are driven at a right angle through two flat boards and bent over (clinched) flush with the wood.
- 2) In end nailing, nails are driven through the thickness of one board and into the end with the grain of another.
- 3) In toe nailing, nails are driven at an angle near the end of one board into the face of the other when two large pieces of lumber must be fastened at right angles.

c. A nailed joint's strength depends on the location and spacing of the nails.

- 1) Stagger the nails if possible.
- 2) Allow adequate separation between nails.
- 3) Do not drive nails in line with the grain.

3. Pulling Nails

- a. If the nail head extends above the surface of the wood, slip the hammer's claws under it.
- b. If the nail head is flush with the surface of the wood, use a pair of pincers or cloven nail pulling tool to extend the head far enough for the hammer claws to slip under it.
- c. Pull the handle of the hammer until it is perpendicular to the surface, then stop.
- d. Place a block of wood under the head of the hammer, and then continue to pull on the handle until the nail is removed.

C. Fastening Wood Joints with Screws

1. Measure the thickness of the boards to be joined.
2. Select a screw length that is three times as long as the thickness of the board being joined unless the screw extends through the second board; in that case, use a shorter screw.
3. Properly space and mark the screw locations.
4. Select a screw diameter that looks in balance with the spacing, closer screws being smaller in diameter.
5. Using a chart, determine the drill size for the shank and pilot holes.
6. Install the pilot hole bit into a hand drill or power drill and adjust the length of the exposed bit to equal the length of the screw.
7. Hold or clamp the two boards together and drill the pilot hole through both boards.
8. Install the shank hole bit into a hand drill or power drill, and use it to enlarge the hole in the first board so that the screw can move freely through it.
9. If a flathead screw is being used, use a countersink tool to make a countersink in the enlarged hole that fits the screw head.
10. Using a screwdriver or screw bit that fits the slot, turn the screw until the two boards are fastened together snugly, but do not over tighten the screw.

D. Fastening Wood Joints with Bolts

1. Select the type of bolt required, usually a carriage bolt since it is designed especially for wood.
2. Select the diameter and length of bolt required.
3. Hold the two boards together and drill a hole through them the same diameter as the bolt.
4. If a machine bolt is being used instead of a carriage bolt, place a flat washer on it, and then insert the bolt in the hole.
5. Place a flat washer on the threaded end of the bolt; a lock washer is often not necessary since the wood provides back pressure on the nut.
6. Place a nut on the bolt and turn it until the boards are joined tightly, but not so tight as to crush the wood fibers or draw the bolt below the surface.

E. Fastening Wood Joints with Glue (White Polyvinyl or Yellow Aliphatic)

1. Make sure the mating surfaces of the two boards to be glued have a good fit and are free of dirt, paint, grease, or wax.
2. Drill the screw or bolt holes if required, and adjust the clamps to fit the boards.
3. Apply small beads of glue on both boards' mating surfaces.
4. Spread the beads of glue out evenly over the mating surfaces.
5. Join the two boards together, and secure them by nails, screws, bolts, or clamps.
6. Check to make sure the joint is properly aligned, and retighten the clamps if used.
7. Using a putty knife or wood chisel, remove the glue runs after they have partially dried.
8. Wipe the glue marks with a clean wet rag, and then wipe them again with a clean dry rag.
9. The clamps can be taken off after 30 minutes, but a stronger bond can be obtained by leaving the clamps on at least 12 hours.

ACTIVITY:

1. Cut and assemble two of the basic wood joints.
2. Practice driving and pulling nails.
3. Fasten wood joints with nails, screws, bolts and glue.
4. Assemble and fasten the pieces of an ongoing woodworking project such as a toolbox or sawhorse. (See Projects Section)

Name _____

Date _____

Score _____

WOODWORKING, UNIT EXAM

A. True and False

1. _____ The working edge or surface is the main edge or surface from which the other surfaces are measured or squared.
2. _____ A crosscut hand saw cuts the wood during the back stroke.
3. _____ Miter joints are stronger than butt joints because they provide more surface contact at the joint.
4. _____ The teeth of a crosscut circular saw blade should point towards you when cutting wood.
5. _____ Nailing is the quickest and weakest method of fastening wood.
6. _____ S4S is lumber surfaced on four sides.
7. _____ The actual size of S4S dimension lumber is 1/4 inch less than the nominal size.
8. _____ Lumber graded as common no. 1, 2, and 3 is suitable for use without waste.
9. _____ Lumber graded as select C or D is suitable for natural finishes.
10. _____ G2S means the veneer of a plywood panel is good on two sides.
11. _____ Good economical construction requires the proper use of the lowest grade lumber suitable for the purpose.
12. _____ File teeth cut only on the forward stroke.
13. _____ A dull circular saw blade is more dangerous than a sharp one.
14. _____ The table saw's primary purpose is to make crosscuts in wood.
15. _____ The thickness of a table saw or radial arm saw's saw cut is 1/8 inch.

B. Matching

1. _____ Perpendicular to the plane of the horizon or in line with gravity.
2. _____ Parallel to the plane of the horizon or having the same height everywhere.
3. _____ Objects positioned so that their edges, surfaces, or ends are even.
4. _____ Lines, surfaces, or planes positioned at right angles (90 degrees) to one another.
5. _____ A sloping edge (less than 90 degrees).
6. _____ Needle-leaf, evergreen trees (conifers).
7. _____ Broad-leaf, deciduous trees.
8. _____ Lumber used for posts, beams, and heavy stringers.
9. _____ Lumber used for sills, plates, studs, rafters, and other framing members.
10. _____ Lumber used for flooring, sheathing, paneling, and trim.
11. _____ Lumber of good appearance and finishing qualities.
12. _____ Lumber containing defects and blemishes.
13. _____ A hand tool used to shave wood to obtain a smooth surface.
14. _____ A crank handle used to turn an auger bit.
15. _____ A tool with gears designed to turn a bit much faster than its handle turns.
16. _____ The stationary saw used primarily for crosscutting lumber.
17. _____ The stationary saw used primarily for ripping lumber.
18. _____ An automatic drill used for rapidly drilling holes up to 3/16 inch.
19. _____ A rectangular groove cut into wood.
20. _____ A joint made by joining to boards face-to-face.

- a. Square
- b. Soft Wood
- c. Level
- d. Timbers
- e. Common
- f. Push Drill
- g. Plumb
- h. Plane
- i. Flush
- j. Hand Drill
- k. Dado
- l. Bevel
- m. Dimension
- n. Table
- o. Boards
- p. Lap
- q. Bit Brace
- r. Hard Wood
- s. Select
- t. Radial Arm

C. Multiple Choice

1. Which function can a combination square not perform?
 - a. Measure distances up to 12 inches.
 - b. Serve as a guide to mark 30 degree angles.
 - c. Serve as a guide to draw 45 degree angles.
 - d. Serve as a marking gauge for marking lines parallel to the edge of a board.

2. Which is the strongest type of nailing?
 - a. Flat nailing.
 - b. End nailing.
 - c. Toe nailing.
 - d. None of the above.

3. Which of the trees below is a hardwood?
 - a. Spruce
 - b. Oak
 - c. Cedar
 - d. Redwood

4. Which of the trees below is used primarily for framing lumber?
 - a. Birch
 - b. White pine
 - c. Yellow pine
 - d. Fir

5. Which wood panel is the most dense?
 - a. Plywood
 - b. Hardboard
 - c. Particle board
 - d. Wafferboard

6. Which of these terms does not refer to the same relationship?
 - a. Perpendicular
 - b. 90 degrees
 - c. Level
 - d. Right angle

7. Which hand saw is held at a 60 degree angle to the surface of the wood it is cutting?

- a. Crosscut saw
- b. Rip saw
- c. Back saw
- d. Coping saw

8. Which hand saw is used with a miter box?

- a. Rip saw
- b. Coping saw
- c. Keyhole saw
- d. Back saw

9. Which hand tool is used to shave wood in recessed areas?

- a. Plane
- b. Chisel
- c. File
- d. None of the above

10. The blade of a portable circular saw should extend through the wood being cut at least:

- a. 1/16 inch
- b. 1/8 inch
- c. 1/2 inch
- d. 3/4 inch

Answer Sheet

A. True and False

1. T
2. F
3. T
4. F
5. T
6. T
7. F
8. T
9. F
10. T
11. T
12. T
13. T
14. F
15. T

B. Matching

1. G
2. C
3. I
4. A
5. L
6. B
7. R
8. D
9. M
10. O
11. S
12. E
13. H
14. Q
15. J
16. T
17. N
18. F
19. K
20. P

C. Multiple Choice

1. B
2. C
3. B
4. D
5. B
6. C
7. B
8. D
9. B
10. B

References:

Wagner, W. H. (1987). MODERN CARPENTRY. South Holland, IL: Goodheart Willcox.

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Jones, M. M. (1955). SHOPWORK ON THE FARM. New York: McGraw-Hill.

Phipps, Lloyd J., and Miller, Glen M.(1998) AGRISCIENCE MECHANICS. Danville, IL: Interstate Publishing

Burke, Stanley R., and Wakeman, T. J. (1990) MODERN AGRICULTURAL MECHANICS, 2ed EDITION. Danville, IL: Interstate Publishing

Special Material and Equipment:

Samples of different kinds of wood and grades of lumber and plywood.

A measuring tape, combination square, carpenter's square, bevel square, level, chalk line, plumb line & bob, sharp pencil, and boards to be marked

Crosscut saw, rip saw, coping saw, compass saw, keyhole saw, bit brace, auger bits, hand drill, push drill, a plane, chisels, files, boards to cut

Portable circular saw, stationary circular saw, radial arm saw

13 oz. curved claw hammer, 16- and 20-oz. ripping claw hammers, various nails, screws, bolts, white polyvinyl glue, clamps, clean rags, standard & Phillips screwdrivers, wrenches, scrap wood

SEE SECTION 130Y FOR WOODWORKING PROJECTS

130I-1

BILL OF MATERIALS

AG 130-I

UNIT OBJECTIVE

After completion of this unit, students will be able to identify the standard measurements of lumber, steel and pipe, complete cost calculations, and know how to use of a bill of materials. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Understand basic terms associated with a bill of materials.
2. Identify the components of a bill of materials.
3. Select from a list of standard measurements in width and length by which most lumber and steel products are sold.
4. Calculate board feet.
5. Calculate cost of materials.
6. Complete a bill of materials.
7. Determine cost of a project.
8. Estimate building materials.

COMPONENTS OF A BILL OF MATERIALS

A. Terms and Definitions

1. Bill of Materials – Itemized list of the number of pieces needed and the dimensions of each for the construction or repair of a project.
2. Board Foot – Piece of lumber 1 inch thick, 12 inches long, and 12 inches wide.
3. Running Foot – Foot length of a material regardless of thickness and width.
4. Square Foot – Equal to a 12-inch by 12-inch surface regardless of thickness
5. Cubic Foot – Measurement 12 inches long by 12 inches wide by 12 inches thick.
6. Surfaced Lumber – Lumber that has been surfaced by running through a planer.
7. Rough Stock – Lumber that has been sawed to dimension but not planed; usually thicker and wider than surfaced lumber.
8. Planer – Machine that smoothes the surface of rough lumber.
9. Gauge – Unit of measurement for thickness of metal. Sheet metal is sold by gauge thickness up to 10 gauge, then metal becomes plate.

B. Bill of Materials

1. Date
2. Name and address of seller and purchaser
3. Project or job
4. Number of pieces
5. Description
6. Dimensions of material
7. Unit cost per kind of material
8. Total cost
9. Name of person who received the materials

C. Standard Measurements

1. Lumber (Standard Length; 6', 8', 10', 12', 14', and 16')
 - a. 1" X 4"
 - b. 1" X 6"
 - c. 1" X 8"
 - d. 1" X 10"
 - e. 1" X 12"
 - f. 2" X 4"
 - g. 2" X 6"
 - h. 2" X 8"
 - i. 2" X 10"
 - j. 2" X 12"
 - k. 4" X 4"
 - l. 4" X 6"

130I-3

2. Plywood (Standard Size = 4' X 8')

a. Thickness:

- | | |
|---------|---------|
| 1) 1/4" | 4) 5/8" |
| 2) 3/8" | 5) 3/4" |
| 3) 1/2" | 6) 1" |

3. Steel (Standard Length = 20 Feet)

130I-5

a. Flat Iron

1) Thickness

- | | |
|----------|----------|
| a) 1/8" | d) 5/16" |
| b) 3/16" | e) 3/8" |
| c) 1/4" | f) 1/2" |

2) Width

- | | |
|-----------|-------|
| a) 1/2" | e) 2" |
| b) 3/4" | f) 3" |
| c) 1" | g) 4" |
| d) 1 1/2" | |

b. Angle Iron

1) Thickness

- | | |
|----------|----------|
| a) 1/8" | d) 5/16" |
| b) 3/16" | e) 3/8" |
| c) 1/4" | f) 1/2" |

2) Width (width of legs)

- | | |
|----------------|--------------------|
| a) 1/2" X 1/2" | d) 1 1/2" X 1 1/2" |
| b) 3/4" X 3/4" | e) 2" X 2" |
| c) 1" X 1" | f) 3" X 3" |

c. Round Stock: Hot and Cold Rolled

1) Thickness

- | | |
|----------|-----------|
| a) 1/4" | f) 3/4" |
| b) 5/16" | g) 1" |
| c) 3/8" | h) 1 1/2" |
| d) 1/4" | i) 2" |
| e) 5/8" | |

d. Pipe, Black or Galvanized (Standard Length = 21 Feet)

1) Schedule relate to wall thickness

2) Size based on approximation of inside diameter

- | | | | |
|---------|-----------|-----------|-------|
| a) 1/4" | d) 3/4" | g) 1 1/2" | j) 3" |
| b) 3/8" | e) 1" | h) 2" | |
| c) 1/2" | f) 1 1/4" | i) 2 1/2" | |

D. Symbols used on the Bill of Materials

- | | |
|---------------------------|--|
| 1. ea = each | 15. S3S = surface 3 sides |
| 2. @ = at | 16. S4S = surface 4 sides |
| 3. " or in = inch | 17. No. or # = number |
| 4. ' or ft = foot | 18. in ² or sq in = square inch |
| 5. yd = yard | 19. ft ² or sq ft = square foot |
| 6. mi = mile | 20. yd ² or sq yd = square yard |
| 7. N/A = not applicable | 21. NC = national coarse threads |
| 8. pt = pint | 22. NF = national fine threads |
| 9. qt = quart | 23. NPT = national pipe threads |
| 10. gal = gallon | 24. d = penny |
| 11. LF = linear foot | 25. lb = pound |
| 12. BF = board foot | 26. oz = ounce |
| 13. S1S = surface 1 side | 27. Cwt = hundredweight (100 pounds) |
| 14. S2S = surface 2 sides | |

E. Types of Bill of Materials

1. Lumber and Hardware (Page 130I-7)

- a. Item
- b. No. of Pieces
- c. Size
- d. Length
- e. Description
- f. Unit Price (per lb, gallon, etc.)
- g. Total Price

2. Steel (Page 130I-9)

- a. No of Pieces
- b. Description
- c. Size
- d. Quantity (lbs)
- e. Price per Pound
- f. Total Price

3. Engine Parts (Page 130I-11)

- a. Parts Needed (Quantity and Description)
- b. Picture Number
- c. Parts No.
- d. Price

F Cost Calculation on Different Types of Bill of Materials

1. Lumber, is sold by the individual board, sheet or by the board foot.

- a. No. of pieces (or BF) X Unit Price = Total Price
- b. Total Price + Cost from other sheet (if needed) + Shop Fee = Sub Total
- c. Sub Total + Taxes + Total Cost

2. Calculating Board Feet and Cost

a.
$$\frac{\text{No. of pieces} \times \text{thickness in inches} \times \text{width} \times \text{length in FEET}}{12}$$

b.
$$\frac{\text{No. of pieces} \times \text{thickness in inches} \times \text{width} \times \text{length in INCHES}}{144}$$

- Example: 1) One board 2" thick X 4" wide X 12' long
 2) One board 2" thick X 4" wide X 144" long

1)
$$\frac{1 \times 2" \times 4" \times 12'}{12} = 8 \text{ board feet}$$

2)
$$\frac{1 \times 2" \times 4" \times 144"}{144} = 8 \text{ board feet}$$

@ 30 cents a board foot
 8 board feet X \$0.30 = \$2.40

Item	No. pieces	Size	Length	Description	Unit price	Total price
board	2	2" X 4"	12'	S2S	\$2.40	4.80

130I-6

3. Steel, is sold by the pound.

a. No. of Pieces X Quantity (lbs) X Price per Pound = Total Price

Example: 1) 2 X 20' X 3.273 X \$0.30 = \$39.28
 2) 3 X 20' X 2.340 X \$0.30 = \$42.12

No Pieces	Size & Description	Length	Quantity (lbs per foot)	Price per Pound	Total price
2	2" X 2" X 1/4" angle iron	20'	3.273	\$0.30	39.28
3	1 1/2" X 1 1/2" X 1/4" angle iron	20'	2.340	\$0.30	42.12

b. Total Price + Cost from other sheet (if needed) + Shop Fee = Sub Total

c. Sub Total + Taxes = Total Cost

4. Engine Parts

a. Parts Needed X Price = Price

b. Price + Cost from other sheet (if needed) + Shop Fee = Sub Total

c. Sub Total + Taxes = Total Cost

PARTS NEEDED	PICTURE NO.	PARTS NO.	PRICE
(1) exhaust valve	33	211 119	9.90

Reference:

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publihsers.

Joseph T. Ryerson & Son, Inc. (1995). RYERSON STOCK LIST. Chicago, IL 312/762-2121

Special Materials:

Price lists from the local lumber and steel supplier.

Price list from Briggs & Stratton, (414) 259-5333 or www.briggsandstratton.com

Activity

1. Use a student's project and make out a bill of materials for that project.
2. Have the students make out a bill of materials every time they make a project.

Name _____

Date _____

BILL OF MATERIALS, QUIZ

Answer the following questions with a short answer

1. What is a Bill of Materials?

2. What is the standard length for steel?

3. List three different thicknesses for plywood.

4. What does the symbol S2S mean?

5. What is the standard length for pipe?

Fill in the Bill of materials with the information below.

You are working on a project that requires eight 2"X4"s ten feet long (\$4.00 ea), five 1"X4"s fourteen feet long (\$3.30 ea), eight 2"X4" joist hangers (\$0.30 ea), quarter of a pound of sheet metal roofing screws (\$14.00 per lb), one pound of 2" wood screws (\$2.30 per lb), seven sheets of 26"X10' ribbed roofing sheet metal(\$11.00 ea), and one gallon of red exterior paint (\$18.50 per gal).

Item	No. pieces	Size	Length	Description	Unit price	Total price
Sub total						
Taxes (Sales tax in Idaho is 5%)						
Total Cost						
Received by _____						

Bonus Question; What kind of project is this material going to be used for?

Answer Sheet

1. A Bill of materials is an itemized list of the number of pieces needed and the dimensions of each for the construction or repair of a project.
2. Steel comes in a standard length of 20'.
3. 1/4", 3/8", 1/2", 5/8", 3/4", and 1" (any three)
4. S2S means, Smooth surface on two sides.
5. The standard length of pipe is 21'.

Item	No. pieces	Size	Length	Description	Unit price	Total price
lumber	8	2"X4"	10'	2"X4", 10', lumber	\$4.00	\$32.00
lumber	5	1"X4"	14'	1"X4", 14', lumber	\$3.30	\$16.50
J/H	8	2"X4"	N/A	Joist Hangers	\$0.30	\$2.40
screws	1/2lb	2"	N/A	Wood Screws	\$2.40	\$1.70
screws	1/4lb	2"	N/A	Roofing Screws, Sheet Metal	\$14.00	\$3.50
metal	7	26"	10'	Ribbed Sheet Metal, Roofing	\$11.00	\$77.00
paint	1	1gal	N/A	Gallon of Paint, Red, Exterior	\$18.50	\$18.50
Sub total						\$151.60
Taxes (Sales tax in Idaho is 5%) 0.05 X Sub total =						\$7.58
Total Cost						\$159.18
Received by _____						

Bonus Question; Roofing project for a car port, patio, storage ,etc.

130J-1

ROPEWORK

130-J

UNIT OBJECTIVE

After completion of this unit, students will be able to identify and care for ropes, know and understand knots, hitches, and their use, know selection, splicing, and use of different ropes. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the students will be able to:

1. List five common uses of rope.
2. Identify samples of natural and synthetic fiber ropes.
3. List the factors to consider when selecting rope.
4. Describe three important practices in rope care.
5. Construct crown, eye, short, and side-loop splices (or make a rope halter, using the splices).
6. Tie three types of common hitches.
7. Tie three types of common knots.

SELECTION AND USES OF ROPE

A. Uses of Rope

1. Ropes are used to secure livestock and pets through the use of halters, leadropes, and leashes.
2. Heavy loads, such as hay and straw, are secured with ropes.
3. Rope is used in rural recreation for water skiing and mountain climbing. It is also used to tie camping gear on pack mules, horses, and vehicles.
4. Heavy objects are lifted and moved through the use of block and tackle.
5. Ropes are used to support trees and shrubs, secure tents, and act as support lines, guide wires, and clothesline.

B. Factors to Consider in Rope Selection

1. Use

- a. Different uses require different kinds, sizes, and lengths of rope.

2. Construction

- a. Rope is made from a variety of materials, each of which has different physical characteristics.
- b. Rope construction varies depending on the material from which it is made. Natural fiber ropes are usually woven while synthetic ropes are often braided.

3. Size

- a. Rope comes in a range of diameters and lengths.
- b. Common diameters of rope are 1/4," 5/16," 3/8," 1/2," 5/8," 3/4," 7/8," and 1."

4. Strength

- a. Rope strength is measured as a breaking load. The breaking load is the amount of weight a rope can hold without being pulled apart.
- b. Rope strength depends on the diameter and the material of which it is made.

5. Flexibility

- a. Flexibility determines the ease with which rope can be handled or worked.

6. Durability

- a. The rope's durability is determined by its ability to resist deterioration when exposed to chemicals, sunlight, water, and abrasion.

7. Cost

- a. The cost of a rope varies depending upon the material from which it is made, the diameter, and the weight.
- b. Rope is sold either by the foot or by the weight.

Table J-1

Safe Working Strength of New Fiber Rope¹
 Working Strength (Pounds)
 Rope

Diameter, inches	Natural Fiber		Synthetic Fiber			
	Manila	Sisal	Nylon	Dacron	Polyethylene	Saran
3/8"	200	150	400	390	300	150
1/2"	440	350	780	745	600	300
5/8"	880	700	1,710	1,355	1,100	620
3/4"	1,080	865	2,000	1,870	1,600	800
7/8"	1,540	1,230	2,700	2,520	2,120	1,140
1"	1,800	1,440	3,600	3,220	2,800	1,600

1. Taken from Rope on the Farm, Farmers' Bulletin No. 2130, United States Department of Agriculture.

2. Actual breaking strengths are at least 5 times the figures given.

ACTIVITY:

1. Complete a chart or matrix that will list the application, type, and size of various kinds of rope.
2. Through class discussion or written quizzes, identify uses of rope around the home, in agriculture, and in rural recreation. Determine the appropriate size and type of rope for varying uses.

ROPE IDENTIFICATION AND CARE

A. Types of Materials Used in Making Ropes

1 Natural Fiber Ropes

- a. Manila rope is woven from the fibers of the Abaca plant, which is native to the Philippines. It is the strongest and most pliable of the natural rope fibers, but it is also the most expensive. Manila rope is susceptible to rot and decay if it becomes wet.
- b. Sisal rope is lighter in color and has a rougher texture than manila. Sisal is made from the fibers of the Agave plant found in Mexico, Central America, East Africa, and the Bahamas. It is not as strong as manila rope, but sisal is more resistant to abrasion. The coarse texture of sisal rope makes it undesirable for use on animals. The older baler twine is made of sisal.
- c. Cotton rope is the most common natural fiber rope used in the United States. Although it is not as strong as manila and sisal, cotton rope is more desirable in livestock handling due to its softer surface texture. Cotton rope is also susceptible to rot and decay and has a tendency to swell when it gets wet, which decreases its workability.

2. Synthetic Fiber Ropes

- a. Nylon and dacron ropes are the strongest synthetic ropes available. They are soft, pliable, and less susceptible to rot and mildew than natural fiber ropes. Although these ropes do stretch when wet, they retain their strength under wet conditions. Excessive heat will melt nylon and dacron ropes and long exposure to sunlight will cause the fibers to become brittle and decay.
- b. Polypropylene and polyethylene ropes have a coarser texture and are less pliable than nylon and dacron. "Poly" rope is also susceptible to damage from heat and sunlight. "Poly" rope is widely used because it is readily available and much cheaper than all other synthetic ropes. Polyethylene rope also floats in water, making it useful for boat and dock work.
- c. Wire rope is normally used for extra heavy pulling or lifting jobs. It is also commonly used in fencing. Wire rope consists of steel wires wrapped around a fiber or smaller wire rope core. The solid core of the wire rope makes it very rigid and difficult to work. The steel must be oiled or greased to prevent rusting. Wire rope is many times more expensive than synthetic and natural fiber ropes.

B. Caring for Rope

1. Inspect ropes regularly for nicks, cuts, and abrasion damage.
 - a. Avoid dragging rope over rough or damaged surfaces.
 - b. Avoid stepping on or laying heavy objects on rope.
 - c. Use synthetic ropes where rope may come in contact with oils, acids, or chemicals.
 - d. Whip or splice the ends of rope to prevent unraveling.
2. Proper storage can increase the longevity of ropes.
 - a. Do not store synthetic ropes where they will be exposed to heat or sunlight for long periods of time.
 - b. Rope should be stored coiled and in a dry place.
 - c. Hang ropes off the ground.

Table J-2

Types of Rope Available for Restraining Livestock¹

Type of Fiber	----- Breaking Strength (pounds) -----				
	3/8"	1/2"	5/8"	3/4"	1"
Cotton	890	1,450	2,150	3,100	5,100
Sisal	1,080	2,120	3,250	4,320	7,200
Manila	1,350	2,650	4,400	5,400	9,000
Polypropylene	2,650	4,200	5,700	8,200	14,000
Nylon	4,000	7,100	10,500	14,200	24,600

Advantages	Disadvantages	Suggested Uses
<p>Cotton</p> <p>soft, flexible</p> <p>least likely to cause ropeburning</p> <p>intermediate in cost</p>	<p>least strong</p> <p>low abrasion resistance</p> <p>will rot and deteriorate</p>	<p>tying of animal limbs</p> <p>neck ropes</p> <p>hobbles</p> <p>lead ropes, if 5/8" or larger</p>
<p>Sisal</p> <p>same as manila, except that sisal is 75-80% the strength of manila</p>		
<p>Manila</p> <p>good strength for natural fiber rope</p> <p>has good "grass" rope "feel"</p>	<p>subject to rotting</p> <p>harsh on hands</p> <p>likely to cause ropeburning</p>	<p>some use as a lariate--not suggested for tying animal limbs (legs)</p> <p>lead ropes, if 1/2" or larger</p>
<p>Polypropylene</p> <p>very strong, second only to nylon and dacron</p> <p>will not rot</p> <p>resistant to barn-yard acids and bases</p>	<p>rope burning is likely</p> <p>flame or heat will cause melting</p>	<p>good for lead ropes</p> <p>excellent for slinging and total restraint</p>

Nylon
highest strength
of any rope
will not rot from
water or mildew

will stretch
very likely to
cause ropeburning
flame or heat
will cause melting

strongest lead
rope available
excellent for
slinging and
total restraint

- d. Wet rope should be dried in the shade in the open air before coiling and storing. This is especially important when handling natural fiber ropes which are susceptible to rot and mildew.
- e. Remove all kinks from the rope before storing.

- 1) To remove kinks, lay the rope out full length and drag one end for about one-half the length of the rope.
- 2) Prevent kinks by coiling the rope in the same direction in which the strands are laid.

- f. Remove all knots from the rope before storing.

- 1) Knots decrease the breaking load of ropes. A single overhand knot decreases the strength of the rope by 65%.

- g. Secure the ends of ropes to prevent fraying.

- 1) Use an end splice or whip the ends of natural fiber ropes.
- 2) Melt the ends of synthetic fiber ropes or dip them in adhesive.
- 3. Lubricate wire ropes with oil or grease and prevent exposure to water to avoid rust problems.

C. Working Safely with Rope

- 1. Most injuries involving the use of rope come from three factors:

- a. Rope burns
- b. Broken ropes
- c. Entanglements

- 2. To avoid injuries from rope burns:

- a. Wear leather gloves when doing work with rope.
- b. Do not wrap the rope around hands when working with livestock.

- c. Do not attempt to grab a rope that is moving under a load, or a fast moving rope.

3. To avoid injuries due to the breaking of ropes:

- a. Never stand, crawl, lie, or walk under heavy objects supported by ropes or cables.
- b. Never tow vehicles with a rope that is not designed for towing. Special nylon ropes are manufactured for this purpose.
- c. Always use a rope with the proper working strength for the job.
- d. Remove all knots from the rope that will reduce the working strength.
- e. Check the condition of the rope frequently.
- f. Never stand near a rope or cable that is under heavy stress. A cable or a rope breaking under these conditions can cause severed limbs and other serious injuries when it whips around.

4. To avoid injuries due to entanglements:

- a. Always stay away from moving ropes.
- b. Never wrap the rope around your hand or body for support.

ACTIVITY:

1. Collect different sizes and types of rope. Have an identification quiz at the end of the period.
2. Have the students practice coiling rope. Divide the class into teams and have a relay race coiling the rope.
3. Bring samples of damaged ropes to class. Inspect the ropes for damage and identify methods of either preventing or repairing the damage.
4. Demonstrate the weakening effect of knots on rope. String can be used instead of thick ropes. Hang objects from the string that has no knots. Then tie overhand knots in the string and see if the same amount of weight will break it.

KNOTS, HITCHES, AND THEIR USES

A. Knots: Knots generally stay tight without the necessity of a steady pull or strain on the rope.

1. The Square Knot is used to tie together two ropes of the same size.
 - a. The Square Knot will not slip and is easy to untie. (Page 130J-14)
 - b. The Square Knot should be distinguished from the Granny Knot which appears similar but binds, is difficult to untie, and will slip.
2. The Sheet Bend (or Carrick Bend) is used to tie together two ropes of unequal diameter. (Page 130J-15)
3. The Manger Hitch is not a hitch, but a knot used to tie livestock to something.
4. The Cat's Paw is used to hold a line to a hook when lifting a load.
5. The Bowline forms a loop that will not slip, yet is easy to untie. (130J-15)
 - a. The Bowline is used to tie around the neck of livestock because it will not tighten and strangle the animal.
 - b. The Bowline is the most common knot used in mountain climbing and rescue work.
6. The Sheep Shank is a knot used to shorten a rope or take the slack out of a rope without cutting it. (Page 130J-16)
 - a. The Sheep Shank can also be used to bypass a damaged section of rope.
 - b. The Sheep Shank depends upon the rope being taut; therefore, slack will cause the knot to untie.
7. The Figure Eight Knot is used to prevent the end of the rope from unraveling or being pulled through a pulley. Most commonly used on tying handles on ropes; for example, starter ropes on lawnmowers. (Page 130J-16)

B. Hitches: Hitches are a temporary method of fastening that depend on the pull of the rope to keep them tight.

1. The Double Half Hitch is used to tie a rope around a post or through a ring or grommet.
2. The Taut-Line Hitch is used to keep a line taut or tight. When used on a tent or a guy line, the tension can be adjusted by pushing the hitch up or down the standing part.
3. The Clove Hitch is used to secure a rope to a post or a pole. (Page 130J-17)

130J-10

- a. The Clove Hitch is used to start and finish many lashings.
 - b. The Clove Hitch is also referred to as an "H-Knot" and is very easy to untie.
4. The Timber Hitch is used to secure logs or objects that will be towed or dragged. (Page 130J-17)
 5. The Trucker's Hitch is used to tighten a line over a load to secure the load. There are several variations to this hitch.

C. Ropework has its own specialized terminology:

1. A bight means to bend the rope back on itself to make a "U."
2. A turn or a hitch refers to the passing of a rope all the way around an object such as a post, a rail, or another rope.
3. A standing line is the main rope that leads to the object being tied.
4. The working line is the end of the rope that is passed around or through so as to actually tie the knot or hitch.
5. To "serve a line" means to wrap a line with cord to strengthen or protect the line and to add a finished look to a splice.

D. Safety considerations must be made before choosing a knot or a hitch.

1. Using a slipknot, or any binding knot, to tie around the neck of an animal or the waist of a person is dangerous. Animals can be strangled and ribs can be broken. Always use a Bowline to tie loops.
2. A Manger Hitch is used as a quick release mechanism for tying animals. If a knot is tied that binds when the animal pulls, the animal can choke if it falls or lies down. A binding knot cannot be untied while the animal is struggling. The Manger Hitch can save the animal's life in this situation.

ACTIVITY:

1. Have the students demonstrate tying the knots and hitches by timing them during a knot relay.
2. Have the students make a knotboard.
3. Have a knot tying station in the shop where students can see knots and hitches and have ropes available to practice tying knots and hitches.
4. Have students practice tying starter rope handle on a lawn mower.
5. Decide which particular knots and hitches are appropriate to use in varying situations.

SPLICING ROPE

A. Splices are used to finish the ends of a rope, join or repair two ropes, or to put an eye or a loop in a rope.

1. A crown and end splice is used to finish the end of a rope. (Page 130J- 18)

- a. The finished diameter of the splice is larger than the diameter of the rope. This causes problems where the end of the rope must be passed through a loop or a ring.
- b. Whipping the ends of the rope can replace a crown splice where the finished diameter is important.

2. An eye splice is often used when a permanent loop is required in the end of the rope. (Page 130J-19)

3. A short splice is used to join two ropes together.

- a. A short splice also increases the diameter of the rope.

4. A side or loop splice is used to put an eye in the middle of a rope. (130J-20)

B. Making Splices and Halters (Page 130J-20)

1. A splice reduces the breaking strength of a rope by 20-35% as opposed to 65% for knots.
2. Splices should be attempted only on three-stranded rope for beginners.
3. A pair of side-cut pliers can be used to trim the rope in order to avoid the use of knives in the classroom.
4. A marlin spike or a 20d nail is useful in separating the strands of the rope.
5. Taping the ends of the strands on natural fiber ropes or melting the ends on synthetic ropes will prevent fraying and make it easier to pass the strands through one another.
6. Eyes or loops designed to have a rope pass through them should be no more than 1 1/2 times the diameter of the rope that is to pass through the eye.
7. Consider the size of the head of the animal (calf, cow, bull, etc.) and the length of the lead rope when determining how much rope to start with.
8. Always finish the splice by rolling it between your hands or under your foot to set the strands.

ACTIVITY:

1. Have the students practice making splices until they are proficient.
2. Have the students combine the different splices they have learned to make a halter.
3. Use a splice relay to motivate students through competition.

ROPEWORK, EXAM

Matching

- | | |
|--------------------------|--|
| 1. _____ Bowline | A. Used to shorten rope |
| 2. _____ Clove Hitch | B. Used to tie up an animal |
| 3. _____ Manger Hitch | C. Used to adjust a tent line |
| 4. _____ Sheet Bend | D. Used to join two ropes of the same size together |
| 5. _____ Sheep Shank | E. Won't slip. Used in rescue work. |
| 6. _____ Square Knot | F. Used to join two ropes of unequal diameter together |
| 7. _____ Taut Line Hitch | G. Starts and ends lashings |

8. Name the three most common causes of injuries in ropework.

9. List five materials used to make rope and the advantages and disadvantages of each.

10. Using the attached chart on rope strength, what size nylon rope would you use to lift a market steer that weighs 1,200 pounds?

11. What is the breaking strength of a 3/4" manila rope?

12. What factors affect the selection of rope for a particular job?

REFERENCES:

Birkby, Robert C. (1990). BOY SCOUT HANDBOOK (10th ed.). Boy Scouts of America, Irving, Texas (Check the telephone book under Boy Scouts of America for name of local retail store or supply house that handles scouting supplies.)

Jurgenson, E. M. (1979). HANDBOOK OF LIVESTOCK EQUIPMENT (2nd ed.). Danville, IL: Interstate Publishers.

Battaglia, R. A., & Mayrose V. B. (1981). Handbook of Livestock Management Techniques. Minneapolis, MN: Burgess Publishing.

RESOURCES:

USING ROPES IN ANIMAL AGRICULTURE (1975). (12 pages).

Available from: Ohio Agricultural Education Curriculum Materials

Service, Room 254

2120 Fyffe Road

The Ohio State University

Columbus, OH 43210-1099

Telephone (614) 292-4848

Special Materials and Equipment:

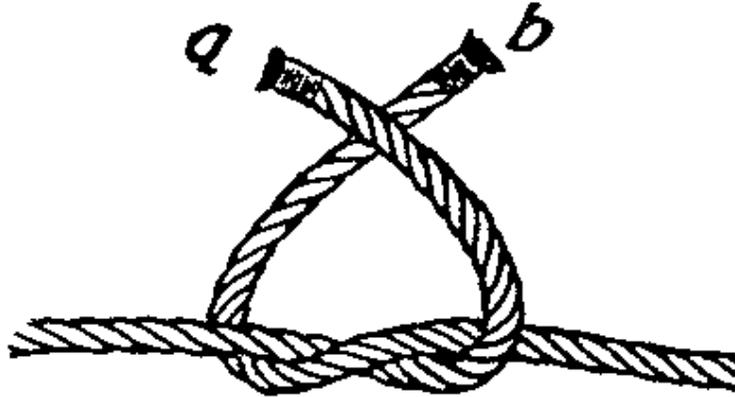
Three-foot lengths of 1/4" or 3/8" rope for each student. Examples of knots on a knot board. For the purpose of this lesson, baler twine can be substituted for rope because it is cheaper and more flexible. Four or five poles for practicing hitches. Samples of nylon, polypropylene, sisal, manila, cotton, and wire rope; also, samples of misused and defective rope. Three- or four-foot lengths of 1/4" or 3/8" three-stranded rope for each student. (To make a rope halter, a minimum of four feet of rope is required.) A knotboard showing examples of the different types of splices.

Answer Sheet, Exam

- | | |
|------|--|
| 1. E | 8. Rope burns, Broken Ropes, Entanglements |
| 2. G | 9. Check the chart on page 130J-6 |
| 3. B | 10 5/8" |
| 4. F | 11. 1,080lbs |
| 5. A | 12. Use, Size, Strength, Flexibility, Durability, Cost |
| 6. D | |
| 7. C | |

130J-14

SQUARE KNOT



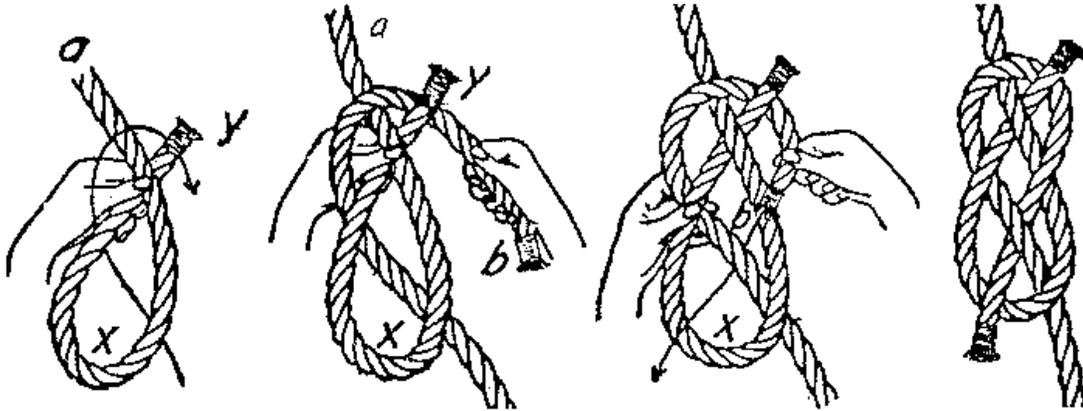
Square Knot – One of the most frequently used and best knots for tying ropes together.
Step 1 – Tie the ends together with a simple right-over-left overhand knot.
Step 2 – Then cross strand A in front of B, and tie a left-hand overhand knot.
Step 3 – Draw tight.

GRANNY KNOT



Note; similar to the square knot but it will not hold under tight tension.

SHEET BEND



Sheet Bend – Used to tie together two ropes of unequal diameter.

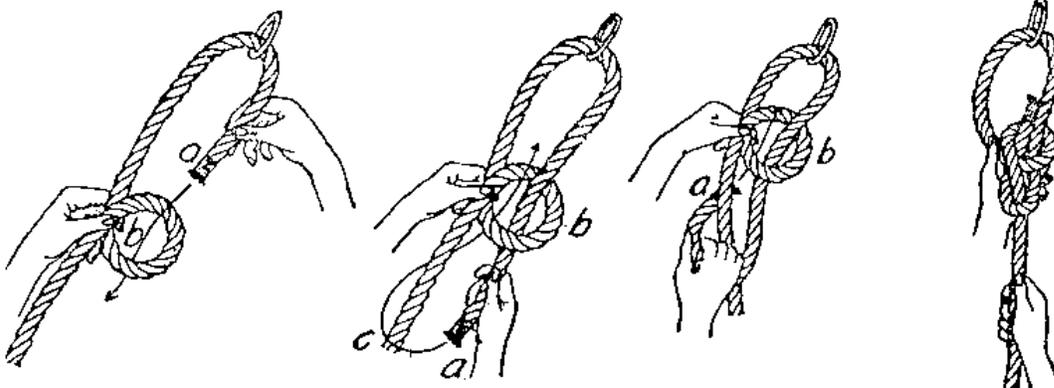
Step 1 – Make a loop in the end of a rope with the Y end under the standing part of the rope A. Hold with the left hand.

Step 2 – Pass the end of the rope B under the loop X, over the standing part at A, and under the end Y.

Step 3 – Hold the knot together with the left hand and continue with end B, passing it over the right side of the loop X, under the standing part of B, then over the left side of loop X as indicated by the arrow.

Step 4 – Hold parts in position and draw tight.

BOWLINE KNOT



Bowline Knot – Most common knot used in mountain climbing, rescue work, and Livestock.

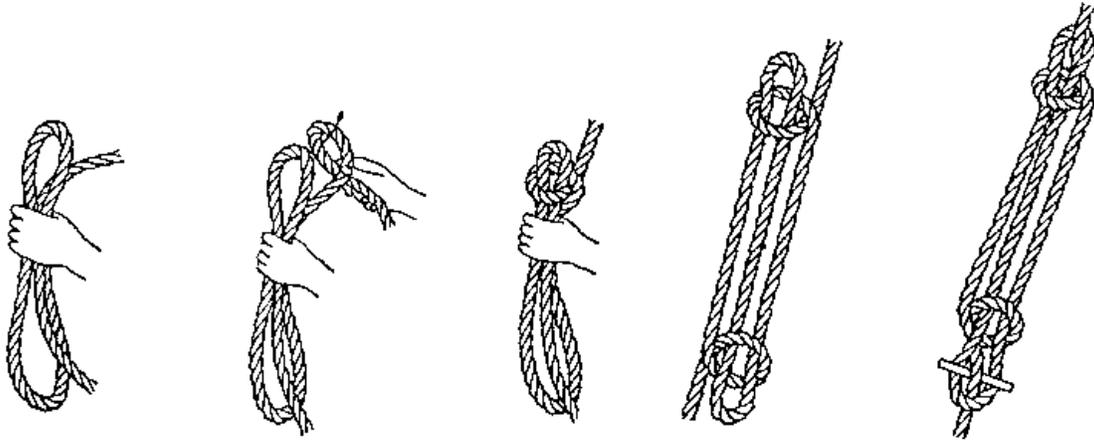
Step 1 – Place the end of the rope through a ring or around a object to which it is to be tied.

Step 2 – With the left hand, make a loop in the standing part of the rope as shown above.

Step 3 – Bring end A through loop B from the upper side, passing it around the standing part of the rope at C, and then up through loop B as shown above.

Step 4 – Draw knot tight.

SHEEP SHANK KNOT



Sheep Shank – Used to shorten a rope or take the slack out of a rope without cutting it.

Step 1 – Make two loops which are long enough to remove the slack. Hold the loops with the left hand.

Step 2 – Make a half hitch, with the right hand, in the rope near one end of the loop and slip it over the end of the loop.

Step 3 – Make another half hitch over the other end of the loop. This completes the hitch.

Step 4 – The hitch may be fastened permanently by passing the ends of the rope through the loops.

FIGURE EIGHT KNOT

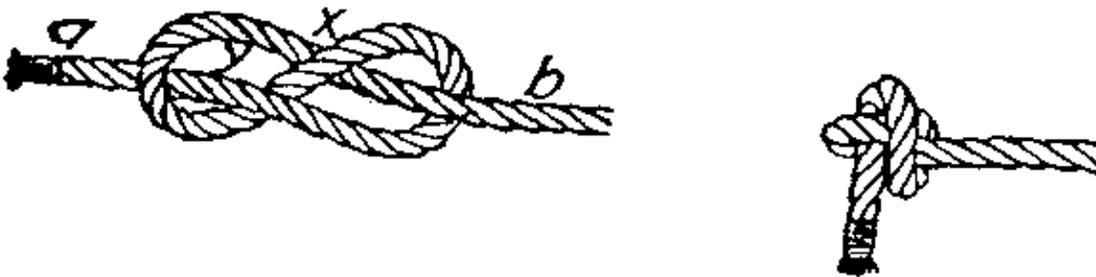


Figure Eight Knot – Most commonly used on Briggs and Stratton lawnmowers with pull starters.

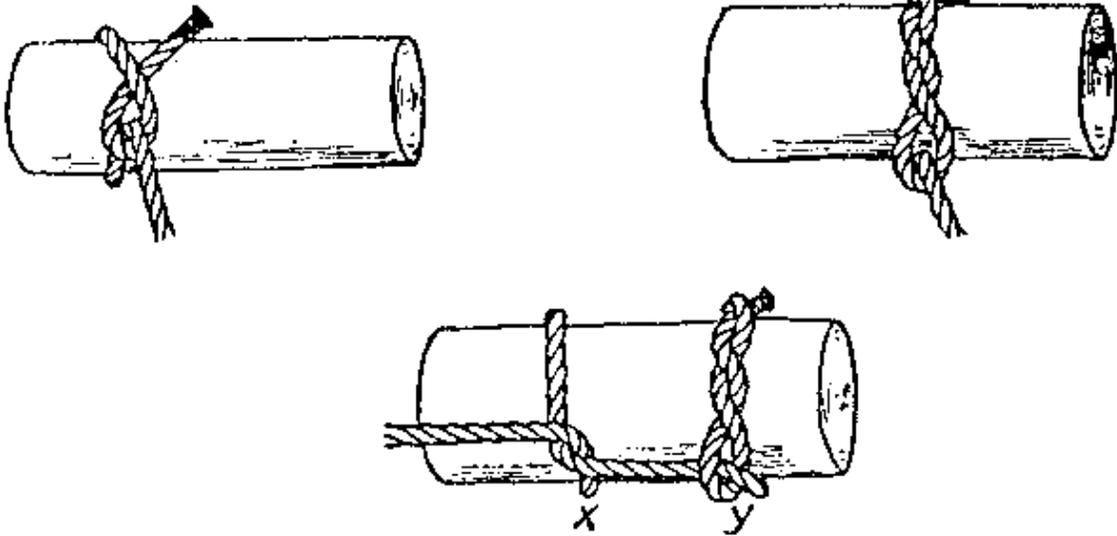
Step 1 – Make a loop near the end of the rope.

Step 2 – Give the short end A, a complete turn around the standing part of the rope B and pass it through the loop at Y

Step 3 – Pull tight.

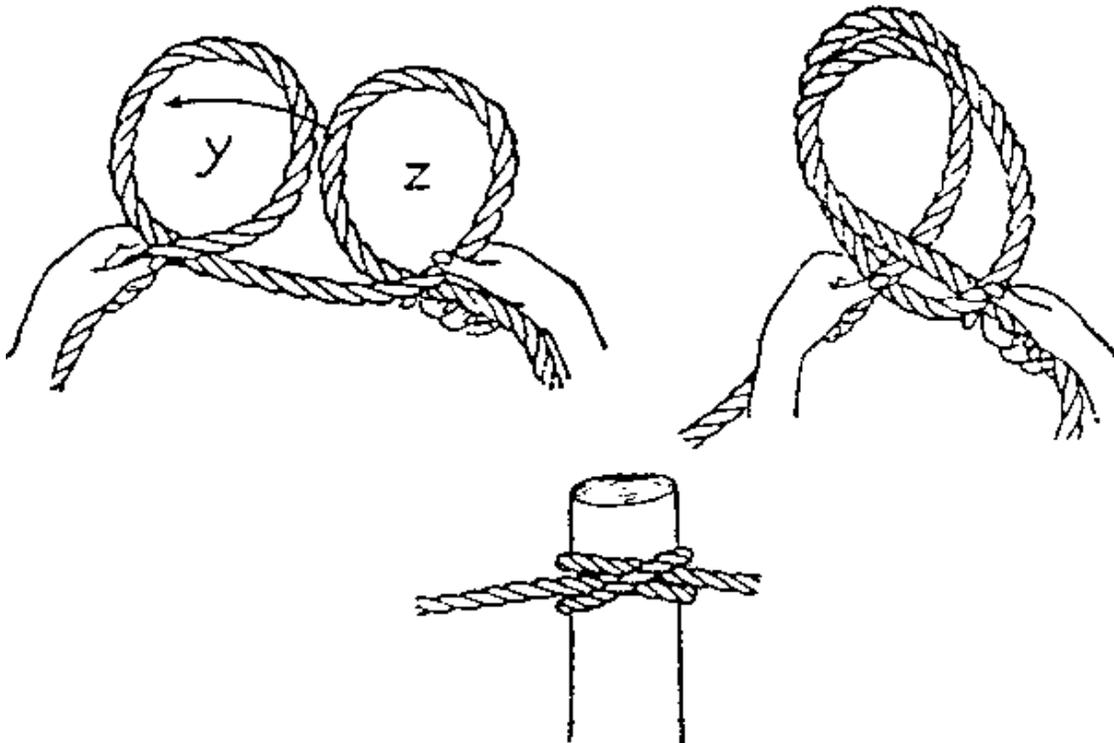
Step 4 – When using this knot for pull starters, place the pin through the loop at Y, then pull tight

TIMBER HITCH AND HALF HITCH



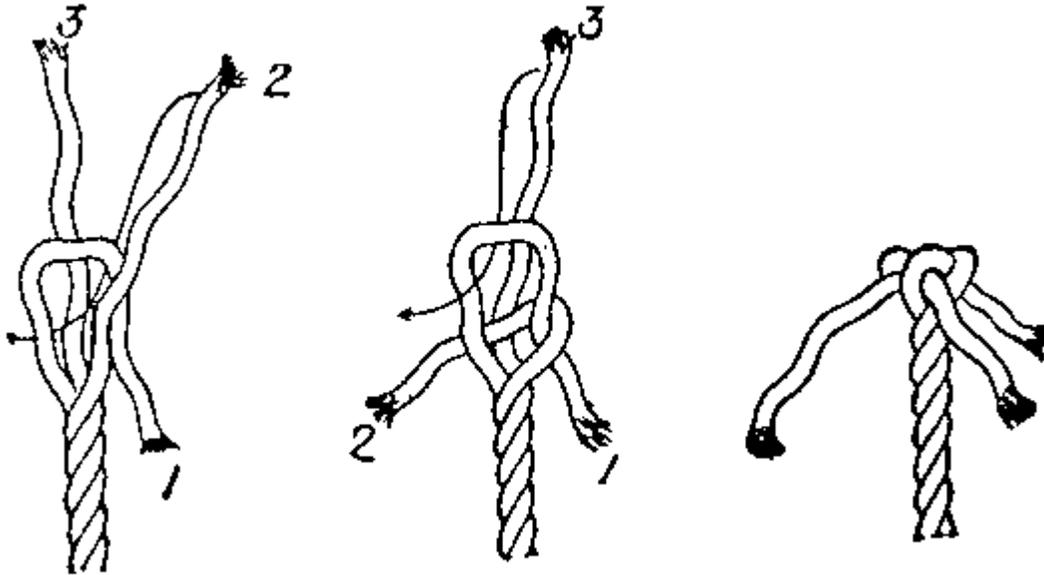
Half Hitch – x Timber Hitch – y

CLOVE HITCH



Clove Hitch – Make two loops in the rope – one to the left, other to the right. Move loop Z over loop Y. Place over the top of a post or stake and pull tight.

CROWN KNOT AND END SPLICE



Crown Knot and End Splice – Used to finish the end of the rope.

ABOVE

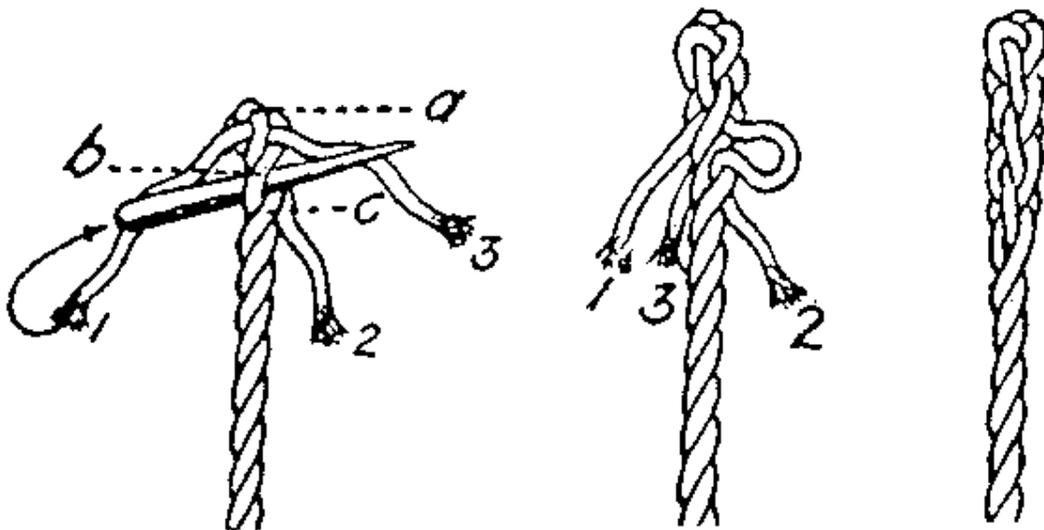
Step 1 – Pass strand 1 to the right over the strand nearest to it on the main rope and under the next strand, pulling it through tightly in a diagonal direction, almost at right angles to the twist of the strands

Step 2 – Handle strands 2 and 3 in the same manner, passing over the main strands next to them and under the following strands.

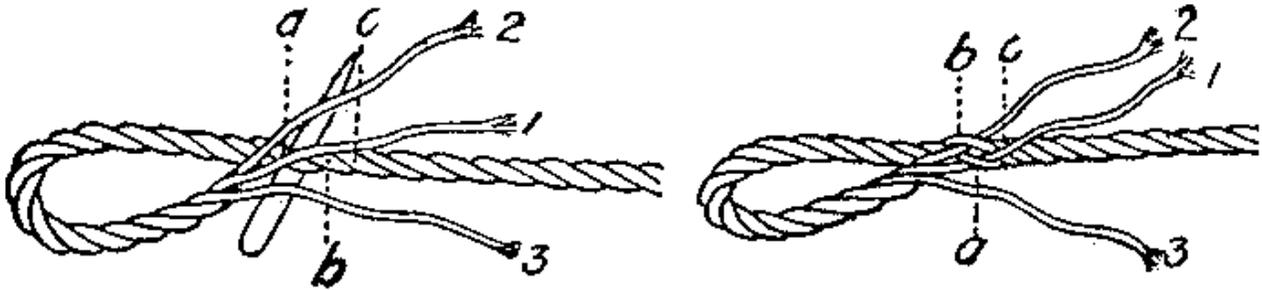
BELOW

Step 3 – Continue with each strand until they have been spliced in, over one strand and under the next for three or four times. A spike may be used to raise the strands.

Step 4 – Smooth the crown by rolling it under the foot and by removing the loose ends. The finished end should have the appearance of the splice below.



EYE SPLICE



Eye Splice – Used when a permanent loop is required in the end of the rope.

Step 1 – Unravel the end of the rope about five turns.

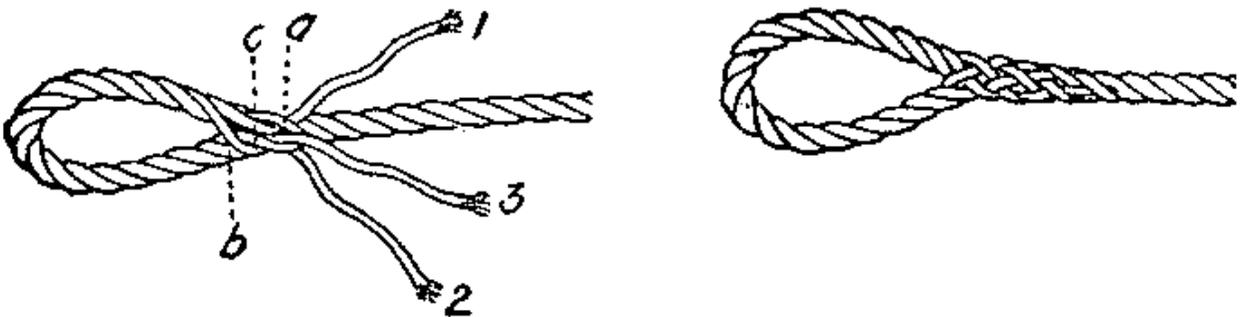
Step 2 – Bend the rope end back on the main part of the rope to form a loop of the desired size. The two outer strands should straddle the rope, the center strand lying on top of the rope.

Step 3 – Raise a strand in the main rope and pass the middle loose strand under it in a direction opposite to the twist of the main rope.

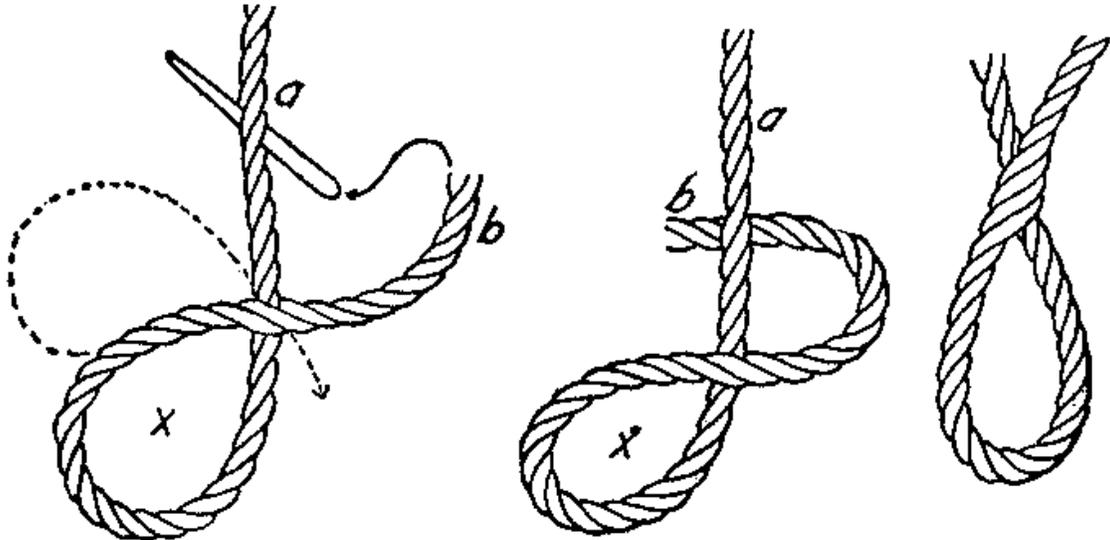
Step 4 – Weave this strand into the main rope, passing it over the strand next to it, under the second strand, and so on.

Step 5 – Tuck in the other two strands in the same manner. Make sure that each loose strand passes over and under but one strand at a time, and that each loose strand is separated by main rope strands.

Step 6 – The finished splice should look similar to the eye splice below



LOOP SPLICE



Loop Splice – Mainly used in rope halters.

Step 1 – Raise two strands in the rope where the loop is to be made.

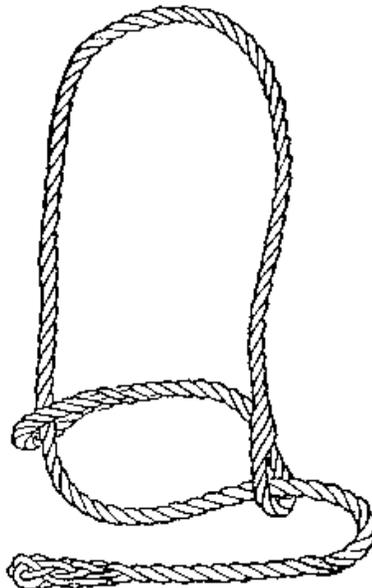
Step 2 – Pass the long end A, which will be the lead rope of the halter through the opening under the raised strands. It is important that the rope A cross under the two strands at right angles to the direction in which they are laid. (The dotted line indicates the improper direction for passing the rope under the strands.) Draw the loop to the desired size.

Step 3 – Raise two strands in the long part of the rope A as indicated.

Step 4 – Pass the short end of the rope through this opening.

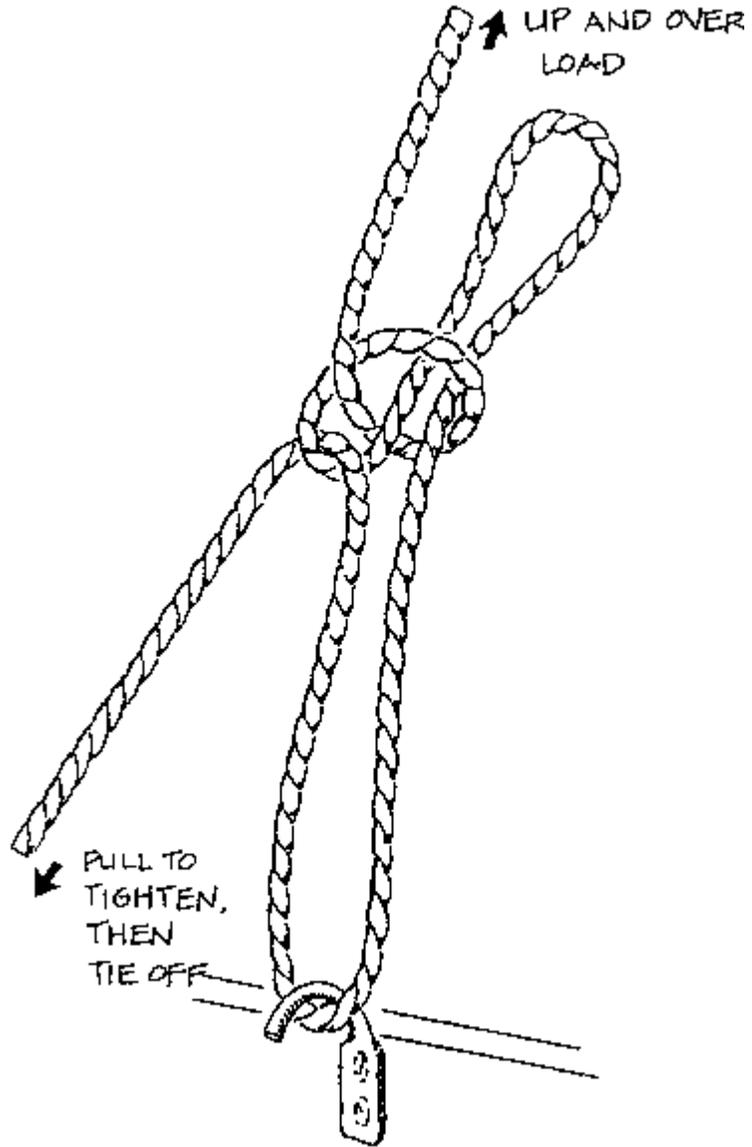
Step 5 – Work the ropes closely together, completing the loop splice as shown above

ROPE HALTER



130J-21

TRUCKER'S HITCH



130K-1

METALWORKING: HOT & COLD

AG 130-K

UNIT OBJECTIVE

After completion of this unit, students will be able to identify common metals, understand and show safe use of metal working tools, and project layout and construction. This knowledge will be demonstrated by completion of assignments and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Identify samples of cast iron, mild steel and aluminum.
2. Identify ten common metalworking tools by type and use.
3. Lay out a drawing on metal for project construction.
4. Make square and circular bends in metal, using an anvil or vise.
5. Determine tap drill sizes for specific applications
6. Use files and saw blades correctly.
7. Join metal by riveting. (Supplemental)
8. Cut threads with a tap and die.
9. Layout and drill holes with a twist drill.
10. Operate power tools such as drills and saws after completing appropriate safety tests.

METALWORKING SAFETY

A. Safety Practices for Working Cold Metal

When working cold metal, observe the following safety practices. When performing cold metalwork, you should know and observe the general as well as the specific safety practices for the hand tools power tools, and portable power tools used.

1. Keep the work area clean. Wipe up oil and grease spills immediately to prevent injuries caused by slipping and falling. Keep paths to exits clear.
2. Use eye protection. When doing cold metalwork, wear approved safety glasses or a face shield.
3. Store rags safely. Store oily and greasy rags in a fireproof metal container to prevent the spreading of spontaneous fires.
4. Use the correct lifting method. Serious injury may result from straining due to incorrect lifting. Lift heavy objects with the leg muscles, not the back muscles. When lifting heavy objects, obtain assistance.
5. Use proper tools. Always use the proper-sized tools and equipment for the job.
6. Obtain the instructor's permission. Use equipment only with the instructor's permission. Notify the instructor immediately if you are injured.
7. Wear proper clothing. Wear clothing that is not loose or bulky and wear hard-toed shoes with non-skid soles.
8. Ground electrical equipment. Each electrical tool should be equipped with a three-prong plug and plugged into a grounded three-hole receptacle. When used outside, portable tools should be connected to ground fault circuit interrupter outlets.
9. Restrain long hair. Restrain excessively long hair with a band or cap to keep hair from getting entangled in machines. When using a drill or drill press, be extremely careful with long hair.
10. Secure stock. Be certain that stock to be cut, filed, or chiseled is securely fastened in a vise or by clamps to prevent tools from slipping.
11. Mount holding devices securely. Mount vises, anvils, and clamps securely for cold metalwork.

B. Safety Practices for Using Hand Tools in Cold Metalwork

Before studying the specific safety practices for using hand tools, review the cold metalwork general safety practices.

130K-3

1. Provide handles for files. Handles on files reduce the possibility of a puncture wound from the file tang.
2. Clean files properly. Use a file card to remove metal from a file. Never use your hands.
3. Never use a file for prying. Excessive pressure on the file while you are prying may cause it to break.
4. Avoid tools with mushroomed heads. Small particles of metal from the mushroomed heads of punches or cold chisels may break off and cause injury.
5. Keep cutting-edge tools sharp. Dull chisels are dangerous as they require excessive pressure and hammering to make them cut.
6. Cut away from bystanders. To avoid hitting bystanders with flying chips, chip and cut in the opposite direction.
7. Carry sharp tools properly. All sharp-edged tools and chisels should be carried with the cutting edge down. Never carry sharp tools in a pocket.
8. Avoid hammers with loose heads. A loose hammerhead is dangerous as it may fly off during use and cause injury.
9. Use the correct hammer for the job. Never use a carpenter's hammer to strike punches or chisels.
10. Watch your fingers. Take special care when you are hammering so that you strike the object, not your fingers.
11. Use a wrench of the proper size. Wrenches that fit improperly may slip and cause injury. Adjust wrenches to fit snugly on a nut to avoid slipping.
12. Pull on wrenches-do not push. Pushing on a wrench is dangerous because the nut may break loose unexpectedly, thus causing skinned or cut knuckles. Always pull with the force on the stationary side of an adjustable wrench.
13. Never extend handles. Handles that are extended with a pipe may break unexpectedly and thus cause injury.
14. Never strike wrenches with hammers. Striking a wrench with a hammer may cause the wrench to bend or break.
15. Use pliers properly. Use pliers for their intended purposes only. Never use pliers in place of a wrench.
16. Do not use damaged wrenches. Because wrenches with badly worn, chewed, or spread opening are likely to slip, they should not be used.
17. Never throw tools. Never toss tools to another worker. The tools may be damaged or the worker may be injured.
18. Keep tools clean. Keep tools and hands clean and free of grease and oil so that you can grip tools properly.
19. Store tools properly. Never leave tools where they may fall, be stepped on, or bumped into. Store tools in a safe location to prevent injury to others and to prevent tools from being damaged.

C. Safety Practices for Using Metal-cutting Band Saws and Power Hack Saws*

Before studying the specific safety practices for using metal-cutting band saws and power hack saws, study the stationary power tools general safety practices.

1. Secure metal in the saw vice. Slipping metal can cause blade breakage and injury.
2. Clean chips from saw properly. Use a brush to clean metal chips from the saw. Never use your hand! Do not attempt to clean the saw while it is running.
3. Handle cut metal carefully. Newly cut pieces of metal containing burrs can cause serious cuts. When handling metal with burrs, wear gloves. Remove burrs from metal as soon as possible.
4. Support long stock. To prevent long pieces of metal from falling, always use a stand to support long stock.
5. Use proper holding devices. Secure irregularly shaped objects in a holding device, such as a V-block for round stock and a drill vise for small objects.
6. Always start a new blade in a new kerf. Because of the set in the new saw blade, the kerf is wider than the kerf made by a used blade. Starting a new saw in an old kerf will ruin the set and may break the blade.

D. Safety Practices for Using Drill Presses*

1. Wear industrial-quality eye protection. Wear safety glasses which are approved and meet the Z87.1 standards.
2. Use good-quality bits. For the safest and most efficient operation, use only straight, sharp, burr, and nick-free bits.
3. Tighten the bit securely in the drill chuck. Use a chuck wrench to tighten the bit in the chuck. Be certain to remove the chuck wrench after the bit has been tightened.
4. Anchor the drill press. An unanchored drill press is unstable and easily turned over.
5. Use proper holding devices. Secure irregularly shaped objects in a holding device, such as a V-block for round stock and a drill vise for small objects.
6. Use a cleaning brush. Remove chips with a brush, not your hands. Cuttings are sharp, and splinters or cuts could result.
7. Avoid seizing. Relieve pressure on the drill just before it breaks through the stock to prevent it from binding, causing the stock to rotate or the drill bit to break.
8. Support the ends of long stock. This will keep undue pressure from being exerted on the drill.

130K-5

9. Never attempt to stop revolving stock with your hands! Do not attempt to stop a revolving piece of stock in which the drill is caught. Cut off the power and then free the bit.
10. Remove the bit from the chuck. After the drilling is completed, remove the bit from the chuck and then place it in its designated place.
11. Attach the vise permanently. Attach the vise to the drill table in such a way that it is permanent but pivatable.
12. When using the drill press, do not wear baggy clothes or leave long hair loose.

SAFETY IN HOT METALWORK

A. Safety Practices for Working Hot Metal

Observe the following general safety practices for working hot metal.

1. Obtain the instructor's permission. Before using any tool or machine, you must obtain the instructor's permission. The instructor must be aware of all laboratory activities and will know if the equipment is in safe working order.
2. Wear industrial-quality eye protection. To protect the eyes from sparks and metal chips, wear approved eye protection.
3. Wear proper clothing. To protect against burns, wear clothing such as coveralls, high-top shoes, leather aprons, and leather gloves. Remove all paper from pockets, and wear cuffless pants.
4. Protect hair and scalp. To protect the hair and scalp, restrain excessively long hair and wear a cap.
5. Know emergency procedures. In the event of an emergency, all students involved in or observing the emergency should call for help immediately as well as assist in correcting the situation. You should know the location of fire extinguishers and fire blankets and how to use them. You should also know the approved procedure for exiting the laboratory.
6. Report all injuries. Report all injuries or accidents to the instructor immediately, no matter how slight. The instructor will secure medical help.
7. Keep work area and tools clean. Dirty, greasy, and oily tools and floors can cause accidents. Clean and put away all unneeded tools and materials. Clean up oil spills and scrap metal from the floor and equipment.
8. Use correct tools. Always use the right size tool and only for its intended purpose. Use tongs or pliers for carrying hot metal.

130K-6

9. Avoid horseplay and loud talk. Loud talking as well as pushing, running, and scuffling while working with hot metal can cause serious accidents. Keep your mind on your work.
10. Work in a well-ventilated area. Fumes and intense heat are part of hot metalwork and require that work be done outdoors or in a forced-ventilated area. This is especially true when you are working with zinc (galvanized iron or pipe), cadmium, or beryllium.
11. Use correct lifting methods. When lifting heavy objects, obtain help. Lift with the legs and not the back. Straining to lift heavy objects can cause serious injury.
12. Store hot metal in a safe place. To avoid the possibility of accidental burns, keep hot metal in a safe place until it cools. Do not offer hot stock to the instructor for inspection.
13. Never touch suspected hot metal. Test metal with moistened finger tips before actually touching it. Use tongs or pliers for handling hot metal.
14. Turn off heat source before leaving work area. Before leaving the laboratory or workstation, make certain the heat source is shut off and cool.
15. Avoid using hot metalwork around flammable material. Do not perform hot metalwork on wood floors or near flammable material. Never work on containers that have been used for storage of combustible material without first having cleaned and safeguarded them.
16. Protect welder cables and hoses when you are hot metalworking. Keep cables and hoses from coming in contact with hot metal and sharp objects. Never point a flame at cables or hoses.
17. Use warm water instead of quenching oil for quenching. Quenching oil is easily confused with other oils. It is difficult to identify. If quenching oil is used, take it from new, previously unopened cans.

B. Safety Practices for Using a Gas Furnace*

Before studying the specific safety practices for using a gas furnace, review the hot metalwork general safety practices.

1. Check for leaking gas. Before firing the furnace, check all the connections with soapy water for possible leaks. This will prevent a possible fire or explosion.
2. Light the furnace correctly. When firing the furnace, keep the doors open and stand to one side. Otherwise ignition may cause the doors to fly open.
3. Use tongs. When removing metal from a hot furnace, always use tongs that fit the stock.

130K-7

4. Use a safeguard system. A gas furnace should, equipped with a safeguard system such as the ultra-violet combustion safeguard system.
5. Use a flint lighter. When lighting a manually ignited gas furnace, always use a flint lighter. Never use matches.

C. Safety Practices for Using an Electric Furnace*

Before studying the specific safety practices for using an electric furnace, review the hot metalwork general safety practices.

1. Avoid electrical shock. Be certain the furnace is grounded and that the electric lead cable is properly insulated.
2. Check grating for scale. Before using the electric furnace, make sure there is no scale on the grating. Scale can short and burn out the coils.
3. Keep the door closed. When the furnace is not in use or is left unattended, make certain that the door is closed.
4. Use tongs. When removing hot metal from the furnace, always use tongs that fit the stock.

SAFETY IN SOLDERING, BRAZING, AND SHEET METALWORK

Before studying the specific safety practices for soldering, brazing, and sheet metalwork, review the hot metalwork general safety practices.

A. Safety Practices for Using a 14-Oz. Propane Torch

1. Wear industrial-quality safety glasses. Wear safety glasses to protect your eyes from spatter and fumes.
2. Use a flint lighter-not matches-to light the propane torch. Matches will bring your fingers too close to the flame.
3. Keep the propane tip pointed away from your body.
4. While using propane torches or cylinders, do not smoke or allow others to smoke because of the potential fire hazard.
5. Turn the propane nozzle off properly. Close the propane tank valve snugly, but do not overtighten. Because the propane tank valve is made of copper, excess pressure will strip the threads. The nozzle should be turned off when there is no flame to prevent propane from escaping and filling the work area with gas.
6. Attach the propane nozzle correctly. Screw on the nozzle tightly to avoid leakage and possible explosion.
7. Remove the propane nozzle from the canister when finished. When you are finished for the day, remove the nozzle from the canister to prevent any gas from escaping.

8. Do not refill propane canisters. Only trained persons should refill canisters. The contents are under pressure and could explode.
9. Dispose of empty propane canisters properly. Do not incinerate empty canisters because they will explode.

B. Safety Practice for Using Electric Soldering Irons

1. Handle the soldering iron carefully. To prevent burns and fire, handle the electric soldering iron with care.
2. Inspect soldering iron cords and plugs regularly. Always inspect the cord of an electric soldering iron for poor insulation before you use it. Unplug the cord when you are finished or interrupted.
3. Do not lay down a hot soldering iron on wood, paint solvents, or other combustible materials.
4. Never solder in a damp area. Stand on a dry board when you are soldering if the floor or ground is damp or wet.
5. Store soldering iron safely. Allow copper to cool before you store the iron.

SAFETY PRACTICES FOR USING A COAL FORGE AND AN ANVIL

Before studying the specific safety practices for using a coal forge and an anvil, review the hot metalwork general safety practices.

1. Secure the anvil. Be certain the anvil is securely anchored so that it will not give under pressure and fall.
2. Keep the anvil's face clean. Keep the face of the anvil dry and free of scale.
3. Strike the anvil properly. Never strike the face of the anvil with a hammer or another object that is as hard as the anvil.
4. Cut metal safely. When cutting hot metal on an anvil, use a handled hot metal cutter and the cutting block or hardy.
5. Protect others. When working with metal on an anvil, warn observers and bystanders to keep back, as metal chips may fly.
6. Keep tools in good condition. Keep forge tools sharp and free of mushroomed heads. Be certain that handles are tight in forge hammers.
7. Use correct tongs. When handling hot metal, always use tongs that fit the stock.

* Reprinted by permission of Interstate Publishers, Inc., from MODERN AGRICULTURAL MECHANICS, 2nd ed., by Stanley R. Burke and T. J. Wakeman. Copyright 1992 by Interstate Publishers, Inc.

ACTIVITY:

1. Draw a floor plan of the shop indicating the power tool positions, bench locations, and doors; show all safety equipment located in the shop.
2. Develop a list of shop tools used in metalworking for a home shop. Price the tools from the local hardware store or a catalog.

IDENTIFICATION AND USE OF BASIC METALWORKING TOOLS

A. Identification and Use of Metalworking Tools

1. Scratch Awl (Scribe) - hardened steel rod with a sharpened point that enables user to make marks on metal.
2. Metal Snips - hand-held pliers-like tool used for cutting sheet metals. Jaws are non-gripping to allow easy release.
3. Ball-peen Hammer - a hammer consisting of two ends, the ball end and the face end. The ball end is used for shaping round edges such as rivet heads, while the face end is used for square work.
4. Hacksaw - hand-held saw with a replaceable blade. The blade should be attached with the teeth facing forward to allow for cutting on the downstroke (forestroke) only. The hacksaw is used for cutting all types of thin metals such as round stock, pipes, tubing, and bar stock.
5. File - a hand-held piece of hardened steel of various shapes and sizes. Files have a heel end which contains the handle and a point end. They are designed to be held at both ends and moved lengthwise over the work.
6. Electric Powered Hand Drill - a hand-held drill motor capable of holding a drill bit. The hand drill is used to drill holes in work that otherwise cannot be carried to a drill press.
7. Drill Press - a mounted drill used for precision drilling of smaller portable objects. The desired location for a hole is marked and center punched. Holes is drilled at appropriate diameter and depth.
8. Taps and Dies - hardened steel tools used to make inside and outside threads. Taps are designed for inner threads or nuts and other holes. Dies are made for outside threads on bolts and other round stock. A hole is pre-drilled for the proper the size tap. Round stock is beveled prior using the die.
9. Pedestal Grinders (bench grinder) - consists of electric motor and spinning stone. Work can be carried to grinder and manipulated for desired outcome.

130K-10

10. Electric Soldering Iron - consists of a handle and soldering lead. Used for waterproofing corners of sheet metal projects by applying quick hardening solder.

ACTIVITY:

1. Have students demonstrate the proper and safe use of each of the ten tools listed above.
2. Design a project which utilizes at least five of the tools mentioned in this lesson.

TYPES AND PROPERTIES OF COMMON METALWORKING MATERIALS

- A. Sheet metal is thin gauge metal used to form ducting, boxes, and machine guards by bending, folding, and otherwise manipulating.

1. Types of Sheet Metal Commonly Used in Agricultural Mechanics

- a. Galvanized or zinc-coated mild steel is the most common type used in the industry. It is available in thickness gauges from 16 ga. to 28 ga. Galvanized mild steel sheet metal is commonly used to build tool boxes, planter boxes, brooders, and anything else requiring durable yet thin metal sheets.
- b. Uncoated mild steel sheet is also available in 16 ga. to 28 ga. This sheet can be used for fence-siding, and other projects which will ultimately be painted.
- c. Copper and brass sheet is often used to do decorative sheet metal work such as name plates and signs.
- d. Aluminum sheet metal, available in different alloys, is also used in decorative applications. It does not rust or corrode easily but is brittle and may crack when worked improperly. In addition to the fastening techniques listed below, aluminum sheet can be welded with a MIG type welder.

2. Material Fasteners Used with Sheet metal

- a. Rivets are used to great advantage with all sheet metal work. Normally the rivet should be the same material as the metal.
 - 1) Size the rivet to fit the rivet hole very close.
 - 2) The rivet should extend 1 1/2 diameters through the sheet metal, then riveted over to form head and hold metal together.

- b. Blind rivets or "pop rivets" are also used in hard-to-get-at places. These are available in steel, stainless steel, and aluminum.
- c. Sheet metal screws provide the ability to easily take the pieces apart and then put them back together. Using a sharp punch to make a hole instead of punching or drilling the pilot hole for the screw provides more material for the metal screw to "bite" into and improves the holding strength.
- d. Machine screws and stove bolts also provide a secure joint and will support more weight than a sheet metal screw. They are also used to attach sheet metal to wood or heavier metal.

B. Metalworking Terms

1. Terms

- a. Strength refers to the ability of a metal to hold loads without breaking. Steel is strong, but lead is weak.
- b. Hardness of a metal refer to its ability to resist penetration, wear, or cutting action.
- c. Malleability refers to its ability of metal to be rolled, forged, hammered, or drawn without cracking or breaking. Gold is the most malleable metal.
- d. Ductility refers to the ability of a metal to be stretched without breaking. Baling wire is very ductile.
- e. Coldwork - Most of the metalwork done in drilling, taping, bending, and forming is done without heat. As metal is worked cold it becomes harder and will tend to crack if done too much. This is called, work hardening.
- f. Heat Treatment - Any heating and controlled cooling process that is designed to produce special properties of hardness, softness, or alteration of the strength of a metal.
- g. Tempering - a metal hardening process done by controlled heating and controlled cooling; it is done to relieve stress in the metal.

C. Iron

1. Types of Iron Commonly Used in Agricultural Mechanics

- a. Cast Iron - coarse-grained steel with a 2-6% carbon content. It is brittle and therefore best used under compression pressure rather than tension. Types of cast iron include gray and white. Cast iron is commonly used for machine parts and hydrants.

D. Carbon Steel

1. Carbon steels are iron which contain a specified percentage of elemental carbon.
 - a. Low carbon steel (mild steel) - contains .05 to .30 percent carbon. Its soft, tough, and malleable characteristics make it suitable for rivets, screws, nails, and low strength machine parts. Used in bar, square, and flat stock it is the most common steel used for a variety of repairs and projects around the agricultural mechanics shop.
 - b. Medium carbon steel - contains .30 to .70 percent carbon. It is used to make bolts, axles, hammers, and screwdrivers.

E. Shapes and Sizes of Steel

1. Mild steel is available in the form of bar, square, and flat stock. This type of stock is measured by its thickness and width. Common lengths are 8 and 16 feet.
2. Sheet steel is available by thickness (gauge) and, as the name implies, is sold in sheets. 4 feet by 8 feet is common.
3. Angle iron, channel iron and "I" beams are forms of mild steel that are measured by thickness, width and-web (internal dimension) size. This form of mild steel is commonly used in agriculture to make frames for equipment and machinery.
4. Round tubing and pipe are commonly used in agriculture for irrigation, fence posts, and transport of fuels. Tubing is generally smaller and is measured by outside diameter (OD) and wall thickness. It is more commonly used in fuel lines and low pressure, low flow water systems. Pipe is generally larger and is measured by inside diameter (ID) and wall thickness. Pipe is used in irrigation as well as fence and building construction.
5. Square tubing is measured by wall thickness and outside dimensions. Square tubing is used for construction of gates and light-duty frames such as bench tops.

F. Aluminum

1. Alloys of aluminum - consist of aluminum plus the addition of small quantities of other metals (copper, silicon, manganese, and others) normally less than 7% or 7% added metal to obtain specific alloys.
 - a. Cast alloys are the basic aluminum material which cast parts are made of by heating to its melting point and pouring in a mold.

- b. Wrought alloys are derived from cast alloy but heated to a specific temperature and then formed by rolling, forging, and/or extruding through a die.

ACTIVITY:

1. Examine samples of different metals of various sizes and shapes, and use technically correct terms to describe them.

LAYOUT AND TRANSFER

A. Planning - An important step in beginning any project is thinking it out. A drawing can assist the thought process.

1. Layout Tools - Both measuring and layout tools require skill in use and care in handling and storage. Provide clean and dry work areas and storage cabinets to house tools. Wipe all metal tools with a lightly oiled rag to protect their finish. Steel wool can return rusted metal tools to usable condition.

- a. A steel rule is used in making linear measurements, checking straight lines, and projecting straight lines onto metal. A steel rule's normally marked in units down to $1/32$."
- b. A scribe is used to scratch the surface of metal when marking or projecting lines. Keep the end sharp with emery cloth.
- c. A combination square set is a very versatile tool for checking the project squareness, centering on a circle or pipe, and developing any angle down to 1 degree by using the protractor head.
- d. A spring divider is used to transfer a dimension or measurement from the rule to the metal. It can also be used to scratch circles or arcs in the metal.
- e. An awl or a prick punch is used to transfer directly from drawing to sheet metal by placing the drawing on top of the metal and then tapping the awl with the palm of the hand to mark the metal through the drawing.
- f. A center punch is used to enlarge a mark for a drill to follow in order to prevent wandering of the drill bit.
- g. A steel pencil with soft, grey, special lead allows the metalworker to mark for rough measurements to about $1/16$ " accuracy. This mark is easily seen and will work on the oil coated surface of most steels.

- h. Soapstone is a white, soft, natural element cut to either a rectangular or round shape about 4" long and used to mark rough measurements on steels for rough cutting.
- i. A combination bevel is a transfer tool used to copy different angles from a blueprint onto metal.

2. Measurement - The first step in correct layout is to measure with exact dimensions the item being copied using a rule, tape measure, dividers, and compass.

- a. The ability to read and measure correctly both whole and fractional dimensions from rule to work and back to the rule requires concentration and counting accurately along the rule.
- b. Practice exercises in drawing lines of specific length (for example, 1 3/16," 5/32," 2 1/8") are recommended before layouts are done on metal.
- c. Practice in measuring and recording pre-drawn lines and listing the correct number and fraction measured is also recommended as a skill building activity.

B. Layout or transfer work is the placement of the measurements and lines or outlines on the metal. It is done in full scale and allows for saw cuts or kerf as needed. The measurements are usually taken off the drawing when laying out, but they may be measured directly from a project being copied or duplicated.

C. Layout of a Project for Construction

- 1. Using the measurement tools previously discussed, determine the proper length and angles required for the project.
- 2. Transfer the dimensions from blueprint to metal using one of several methods discussed above.
 - a. Attach a drawing (full size) of the project to the metal. Using a scratch awl, make an outline of the project on the metal.
 - b. Transfer lines from a blueprint to metal using a straight edge and soapstone or chalk. Be sure all lines are straight and angles are correct.
 - c. Use templates or cardboard, etc., to transfer curves and angles.

ACTIVITY:

1. Draw a paper layout of a parts box and then cut it out and fold it into its finished shape.
2. Measure an object like a simple box and then transfer the measurements to a paper layout drawing in full scale. When the layout is complete, including the dimensions, transfer the drawing to the metal, using a scratch awl.

SHEETMETALWORKING

A. Sheet metal Tools

1. Cutting Sheet metal

- a. A cold chisel is used with a hammer and a vise to shear the metal when only the piece in the vise is to be saved.
- b. Tin snips are available in several sizes and jaw shapes; they are used to cut metal as thick as 20 gauge by hand.
- c. A hand notcher removes a small notch from the edge of a piece of metal in order to allow the metal to be bent in a circle to the inside or to the outside.
- d. A hand punch is a 'C'-clamp shaped tool which uses an inside punch and outside die to cut holes in sheet metal. The size can quickly be changed to the desired diameter.
- e. Aircraft shears or compound snips come in right hand cut, left hand cut, and straight cut depending upon the shape being cut. They make use of compound leverage action for easy cutting and have a slightly serrated cutting edge to grip the metal.
- f. A squaring shear is a foot operated cutting shear which will cut a full width sheet of metal in one cut. It is used to make long cuts and produce smaller pieces for use as projects.

2. Bending and Folding Tools

- a. A setting hammer is a small 6-8 oz. hammer with a square-shaped face on the head and a sloped or slanted peening end used to close sheet metal down around a wire.
- b. A tinner's bench plate and stakes consists of a large, heavy plate of cast steel with a series of square holes that accept many different kinds of shaping stakes used in bending and forming sheet metal.

130K-16

- c. A hand seamer is a pliers-like tool with long, flat, smooth jaws that grip the sheet metal in order to fold it over or partially bend it.
- d. A hand crimper shortens one side of an angle in order to allow it to be curved to the inside.
- e. A sheet metal brake is a hand- or foot-operated bending machine that is wide enough to allow large pieces of sheet metal to be bent at one time along a single line. It can usually bend up to 120 degree angles.
- f. A sheet metal roll former is a hand-operated machine that uses three rollers to bend the metal around itself to form a tube, a ring, or a curved metal piece.

B. Sheet metal Layout

1. Project Selection

- a. Select a simple project such as a small tray or box.
- b. Include in the project seams, hems, tabs, holes, folds (bends), and notches.
- c. Use a thin gauge metal to make the project (24-26 gauge).
- d. Draw the project on paper, then cut out and fold the paper template before doing the project in metal.
- e. When the paper template is correct, place the template over the sheet metal and tape it down. Using the awl, prick a small indentation through the template and into the metal at each intersecting point of lines. This forms a "dot-to-dot" on the metal which can then be connected with the scribe to form the outline and bend lines of the project.
- f. Finish the project by soldering all the tab joints so they are watertight when tested.

C. Cold Metal Riveting

- 1. Riveting can be done with or without heat. Cold metal riveting is used with small rivets and/or small riveting jobs. The process is as follows:
 - a. Mark, center punch and drill a hole slightly larger than the diameter of the rivet.
 - b. Load the rivet into a pliers-type pop-riveter being sure that the rivet is tightly held.
 - c. Place the free end of the rivet through a pre-drilled hole and squeeze the handle of the pop-riveter. (It normally requires two (2) squeezes of the handle to properly set the rivet.)

- d. The rivet can be flattened by placing the project on an anvil and striking it with a ball peen hammer.

2. Soldering Process

- a. Cleaning - Since soldering is an alloying process, the base metals must be very clean in order for the solder to adhere to the surface of the metal.

- 1) Pre-clean with steel wool, wire brush, or emery cloth.
- 2) Use a 50% solution of muriatic acid and water in order to remove grease, wax and metal oxides from the base metal. (Caution: Eye protection and other safety procedures should be followed when soldering or preparing to solder.)
- 3) Acid and/or rosin flux are used during soldering for the following reasons:
 - a) They remove any final oxides of the base metal just before soldering.
 - b) They prevent or minimize oxidation while the base metal is being heated.
 - c) They aid in the flow of heat to the base metal and protect the solder from oxidation while it is molten.
- 4) Note: Wash sheet metal with water when finished soldering in order to remove any traces of acid or flux and to prevent metal corrosion.

- b. The base metal pieces must be heated to just above the melting point of the solder and kept at this temperature while the soldering is being done.
 - 1) A light coat of solder is sometimes applied to the surface of the metal and rubbed along with steel wool to tin the surface before going back and completely soldering the joint.
 - 2) Several sources of heat may be used to solder:
 - a) Blowtorch and soldering copper
 - b) Electric soldering iron
 - c) Propane hand torch bottle

130K-18

d) Electric soldering gun (usually used for small work)

3) Heat evenly and feed the solder into the metal at the point of application of the heat. (The molten solder will seek the heat and capillary action will draw the solder into the joint.)

ACTIVITY:

1. Practice cutting, drilling, and bending sheet metal.
2. Practice cold riveting on sheet metal.
3. Design and build a simple sheet metal project such as bookends or a coal scoop.

COLD METALWORK

A. Working metal cold is an easy and economical method of forming metal into various projects in a short time. Cold metalwork is the process of hand bending, drilling, taping, and cutting soft steels. It is one of the major types of manufacturing used to produce livestock and farm machinery (and equipment).

B. Metalworking

1. Tools Used to Cut Cold Metal

- a. A hacksaw is a stiff-backed, bow-type saw with a replaceable metal cutting blade. There are from 16 to 32 teeth per inch.
- b. A cold chisel is used with a hammer to cut through bolts and round stock or to cut sheet metal. Cold chisels come in various sizes.
- c. A bolt cutter is a large-jawed cutting tool which can be used to cut round steel rods and soft bolts or small-square shaped steel bars.

2. Bending Metal Cold

- a. Vise - The standard shop vise with 3" to 5" size jaws works very well to secure and hold light steel to hand bend or form the metal to shape. Bending can also be done by allowing the jaws of the vise to remain open and use the pivots to bend gentle curves in strap steel and rod or pipe.

- b. Adjustable Open-end Wrench - A Crescent wrench is a suitable leverage device to cold bend the lighter steel shapes. A short length of pipe or a large hammer can also be used.
- c. To make a square bend: Clamp metal in the vise so the point of the bend is flush with the top of the vise jaw. Using a ball peen hammer or a rubber mallet, bend the metal by lightly striking just above the vise jaws (point of bend). Check for proper bend (90 degrees) using a square.
- d. Circular bends may be accomplished in one of several ways.
 - 1) Fashion a jig out of 2 short pieces of pipe (size will be determined by desired degree of bend) and a flat piece of iron. Weld the pipe onto the iron at the desired distance. The jig can then be clamped into the vise. The metal can be placed between the jig pipes and manipulated for the desired bend. This procedure works best with strap steel and rod.
 - 2) Bend shallow curves by manipulating the metal around the open jaw of the vise.

4. Filing Metal

- a. Files are used to remove small amounts of metal and to shape and smooth the surface. A file card should also be available to clean the file as needed.
- b. File Shapes - The shape of the file selected depends on the amount of contact surface to be filed or grooved.
 - 1) Round - Round files come in different diameters and have a slight taper to the length of the file. It is not like a chainsaw sharpening file which is straight.
 - 2) Flat - flat files come in many different cuts:
 - a) rough cut d) second cut
 - b) coarse e) smooth
 - c) bastard f) dead smooth
 - 3) A triangular file has three cutting sides and a narrow face.
 - 4) A half round file has one flat face and one rounded face.
 - 5) A knife file has two flat faces which come together as a sharp side or knife edge along one side.

c. Safe Use of Files

130K-20

- 1) Files should be cleaned with a file card whenever necessary.
- 2) All files should have a handle in order to prevent injuries to the hands.
- 3) Files should be held by both the front end and the handle. Hold the front end between the tips of the fingers and the thumb. Allow the file handle to rest in the palm of the hand.
- 4) Push the file forward with light yet steady pressure. Draw back with light yet steady pressure. Repeat steps as necessary.

5. Drilling Metal

- a. Punch mark a good center point before drilling. Go deep enough to allow the drill to center up on the mark.
- b. Twist drills come in three common sets or index groups and also a metric index.

- 1) Fractional Index - twist drill sizes from 1/16" diameter to 1/2" diameter by 64ths of an inch.
- 2) Lettered Index - twist drills from letter size 'A' to 'Z'; the letter 'A' is small and the letter 'Z' is big.
- 3) Numbered Index - twist drills from number 1 to number 60; number 1 is medium while number 60 is very small.
- 4) Metric Sizes - change by one millimeter per drill size.

c. Drilling Procedure (drill press, portable electric hand drill)

- 1) Punch mark for a good center.
- 2) Select the correct size drill for the job.
- 3) Consult a drill speed chart to determine what RPM the drill should be operated (1/2" drill = 458 RPM). Change the drill press drive to the correct speed.
- 4) Chuck the drill securely into the drill press and check to see that the drill spins true.
- 5) Use a good quality cutting oil to lubricate and cool the drill while it is being used.
- 6) Use safety goggles when drilling with the drill press.
- 7) Drill with an even down pressure, but still allowing the drill to cut through the metal instead of being punched through. Relax the down pressure just before the drill breaks through the opposite side.

6. Taping Threads in Metal (threading the inside of a hole)

- a. Thread Sizes - All machine screw and bolt threads are straight cut threads which means that the first thread cut and the last thread cut are the same depth. The number of threads per inch varies depending upon the strength and torque required for the job and the size of the screw or bolt.
- b. Thread Pitch - This is the term given to the angle that the threads make to the head of the bolt. A coarse pitch will not hold as well as a fine pitch. These are usually referred to as national coarse and national fine thread bolts.

- 1) example: 1/4" diameter X 20 tpi National Coarse
- 2) example: 1/4" diameter X 28 tpi National Fine

- c. Selecting a Tap Drill - The tap drill is the correct size twist drill used to pilot just the right size hole through the metal to be followed by the selected tap.

- 1) A tap size chart with corresponding tap drill size is listed below:

NATIONAL COARSE THREAD CHART

Size Thread	Threads/inch	Tap Drill Size
1/4"	20	#7 (13/64" approx.)
5/16"	18	#F (1/4" approx.)
3/8"	16	5/16"
7/16"	14	#U(23/64" approx.)
1/2"	13	27/64"
9/16"	12	31/64"
5/8"	11	17/32"
3/4"	10	21/32"

NATIONAL FINE THREAD CHART

1/4"	28	#3 (7/32" approx.)
5/16"	24	#I (17/64" approx.)
3/8"	24	#Q (21/64" approx.)
7/16"	20	25/64"
1/2"	20	29/64"
9/16"	18	33/64"
5/8"	18	37/64"
3/4"	16	1 1/16"

7. Using a Tap

- a. Taps vary by thread cut as well as the shape of the tap. There are three types of taps:
 - 1) Taper Tap - This has a long, slender, easy starting entry into threading cutters, but must be allowed to tap entirely through the metal piece in order to cut all threads to the specified depth.
 - 2) Plug Tap - This has a medium entry into the metal and can also be used to start the thread, but should continue the threading all the way through the metal.
 - 3) Bottoming Tap - This tap does not start threads very well but will cut the thread all the way to the bottom of a blind hole which will then accept a bolt almost all the way to the bottom.
- b. Starting the tap in the metal straight and keeping it straight is the most difficult part of this job. Work slowly and align the vertical axis of the tap perpendicular to the surface of metal being tapped. Use a gentle but firm down pressure on the tap handle.
- c. Turn the tap several turns to get a good bite on the metal. Then as the tap is turned into the metal each half to full turn, back the tap up enough to break off the metal chip being cut (about one fourth turn).
- d. Be sure to clean all threading material out of the threads before they are used to twist in a bolt or screw.

8. Using a Die

- a. Putting threads on the outside of a rod to form a bolt is done using a die and die stock or handle.
- b. The dies also cut standard threads in National Coarse and National Fine sizes to match the taps discussed previously.
- c. Cutting threads involves most of the same procedures used in tapping threads with these additional hints:
 - 1) Select the correct die thread size to go with the tap threads used or with a nut already selected. Set the alignment marks on the die cutters to be just across from one another. This will cut a standard clearance thread fit between the inside and outside threads.

- 2) Grind the tip of the rod to be threaded with a slightly chamfered end in order to allow the die to easily start straight.
- 3) Start the die with an even down pressure and hold the die stock level so the threads start an even cut.
- 4) Turn the die clockwise for one half to one full turn and then back off one fourth turn to clear the chips from the die.
- 5) When the threads have been cut as long as required, back the die off the threads and clean on a wire brush.

9. Using Power Tools for Cold Metalwork

a. Power Hacksaw - This is a band-type saw designed to cut all metal angle, bar, strap, channel, pipe, and other shapes of construction steel. This saw is easy to operate.

- 1) Clamp the work firmly in the vise of the saw, at the desired cutting angle, in such a way that the most teeth of the blade will come in contact with the work when cutting begins.
- 2) Turn on the saw and lower the blade until it begins to cut and then set the balanced cutting weight of the saw to work.
- 3) The automatic shut-off of the saw should stop the saw when the piece has been cut through.

b. Power Drill Press - A drill press can be either a floor model or a shorter bench model; both operate equally well.

- 1) When using a drill press always use a drill press vise to secure the work and assure a quality drilling job.
- 2) First select the correct drilling speed from the chart provided with the drill press. The speed (RPM) depends on the size of the drill; generally, the larger the drill size the slower the speed.
- 3) Place the drill bit in the chuck and tighten it using the chuck key. Then check to see that it spins true before turning on the drill press.
- 4) Check next to see if the drill is located and centered on the center punch mark already placed in the work.

- 5) Start drilling slowly to check the center alignment and then place a small amount of cutting oil in the hole and continue to drill with even pressure. Apply more cutting oil as the drilling progresses.
- 6) When close to finishing, relax the down pressure in order to go through the opposite side slowly.

ACTIVITY:

1. Select a tap drill for several different tap sizes.
2. Lay out several cuts and hole centers on a piece of steel and then cut, drill, and tap the material.

HOT METALWORK

A. Using heat to help soften metal and then using controlled cooling for hardness and stress relief have been done by blacksmiths for many years.

1. Welding was originally done by heating two pieces of metal to a red hot temperature and then hammering the two together on an anvil.
2. Cutting, punching, upsetting (shortening), drawing out (lengthening) are all hot metal procedures used by the blacksmith.

B. Hot Metalworking Tools

1. Types of Forges

- a. Permanent natural gas fired forges are good for heavy metal work and inexpensive to operate. (The original forges used coal.)
- b. A portable propane fired forge is the best forge for most school shop use because it stores easily and provides ample heat.
- c. The chimney of the forge is used in order to get a good draft. Ample ventilation must be used with a forge and fire precautions must be taken when using this high heat source.

2. Anvils and Bases

130K-25

- a. Anvils are made and purchased by weight. A good size for a shop anvil is 150 pounds. (Some portable anvils are only 60 pounds and other anvils are made for special purposes) such as horseshoeing.
- b. The anvil base must be of a solid but absorbent material. The best base is made of a large round of oak or other hard wood cut to allow the height of the face of the anvil to be touching the knuckles of a fist when standing by the anvil with the hand held down. Concrete can also be used and is preferred by some.

3. Other Equipment Needed

- a. Blacksmith's ball peen hand hammer, 1 lb., 10 oz.
- b. Machinist's hammer, 1 lb., 8 oz.
- c. Blacksmith's cross peen sledge, 10 lb.
- d. Machinist's vise
- e. Hardie to fit anvil, used to cut metal when hot
- f. Hot cut chisels
- g. Tongs, straight-lipped, 1/4" opening, 18" length
- h. Tongs, bolt, 3/8" to 1/2," 18" length
- i. Water bucket or quenching tank

C. Hot Metalwork Procedure

1. Holding the Stock - Because burns are a potential problem with hot metalwork, the correct method of holding the metal is very important.
 - a. Select tongs that fit the work.
 - b. Keep the tongs cool by dipping them in water.
2. Measuring Stock - Use chalk to measure the stock. Use a center punch or file to mark the exact point to be heated.
 - a. For a curved piece of metal, use a light piece of wire to form a shape template and then straighten the wire and measure its length.
 - b. To make a ring, the amount of metal needed is three and a half times the diameter of the ring plus half the diameter of the stock.
3. Heating the Stock - Caution must be used when heating metal in order to avoid having the metal reach a "white heat" stage where it will oxidize or burn.

130K-26

- a. Heat should be evenly applied to the entire area to be worked.
 - b. For welding operations, bring like pieces to the same temperature together.
 - c. Determine what amount of heat is necessary to do the job and use no more heat than is needed.
4. Annealing is the heating and slow cooling of metal done in order to soften it and remove stress.
- a. To anneal iron and steel, heat the stock slowly to a uniform red color and bury the stock in air-slack lime, pulverized charcoal, or wood ashes.
 - b. Remove the metal only after it has completely cooled.
5. Tempering - The hardness and brittleness of steel for certain purposes is controlled by how it is heated and cooled. Tools such as chisels, hammers, picks, and shears are tempered to last a longer time or maintain their cutting edge.

NOTE: Not all steels can be tempered successfully. Use a high quality tool steel for best results.

- a. To temper, heat the piece of metal to a cherry red color. (Never heat tool steel to higher than a bright red or a low-orange heat or it becomes coarse-grained and weak.)
- b. Dip the end to be tempered into water while moving it up and down slightly in order to cool the tip rapidly (this will harden the tip).
- c. Remove the tip from the water while the other part of the metal is still red hot; this allows the heat to creep back into the cooled end.
- d. Brighten the cooled end immediately with a file and watch for the colors to move back into the cooled end. (See color chart below.)
- e. When the desired color has just reached the cooled end, immediately plunge the end back into the water and stir the water as before.
- f. Finally, when the piece has returned to a black color it may be totally submerged in the water for complete cooling.

6. Tempering Color Chart: (Chart shows hardest first.)

a. Project:

1) Lathe Cutting Tools Hammers	Light Straw Color
2) Punches Taps and Dies Drills Reamers Knives	Dark Straw Color
3) Axes Shears	Dark Brown Color
4) Cold Chisels Center Punches Rivet Sets	Purple Color
5) Screwdrivers Springs Gears Picks Saws	Blue Color

7. Bending and Shaping with Heat

- a. Heating large pieces of metal that are to be bent allows the metal to work easier and make a sharper bend.
- b. Correct heating and bending will retain the strength of the metal while it is worked. Never over-heat the metal. Normal heating temperature is reached at a dull cherry red color.
- c. When using a hammer to form the bend, hit blows hard but as few times as possible in order to prevent a coarse grain from forming as the steel cools.
- d. Never continue to bend or shape when the color has left the steel. Hammer only when the metal is still red hot.
- e. Twisting stock can also be done with heat and should follow the same procedures as above.

8. Cutting Metal Hot

- a. Hot metal may be cut with a hammer and hardie on the anvil as well as with a hot chisel.
- b. To cut the metal, heat it to a cherry red color and lay it across the hardie at the point it is to be cut. (The hardie goes into the Hardie hole in the anvil.)
- c. Hit the metal piece with the hammer directly over the hardie and slowly rotate the piece so a groove forms at the point of the cut. When the groove goes entirely around it, hold the piece at the edge of the anvil and strike a sharp blow to break off the excess.
- d. Lighter stock can be cut directly over the hardie simply by hammering through it.

9. Drawing Out

- a. Lengthening or slimming a piece of metal is termed drawing out. It is done in the following way:
 - 1) Heat the stock to a white heat.
 - 2) Place the stock on the anvil and use a hammer to strike slight glancing blows. Have the hammer glance off in the direction the stock is to be lengthened.
 - 3) While hammering, turn the stock slightly so it will be hammered evenly on all sides.
 - 4) To change the stock from a square cross section piece to a round cross section piece, first hammer the square to an octagon and then round the corners of the octagon to a round shape.
 - 5) Hammer evenly on all sides and hold the piece at the correct angle to the face of the anvil so the piece will not be bent while it is being hammered.
 - 6) Reheat the stock when it cools below a cherry red color. Do not hammer without color!

10. Upsetting

- a. Shortening or thickening a piece of metal is termed upsetting. It is done in the following way:
- b. Heat the part of the stock to be enlarged to a white heat.
- c. Place the stock in a vertical position on the face of the anvil in order to prevent bending.

- d. Strike the cold end of the work with hard blows from the hammer. If the piece bends, quickly place it flat on the anvil and hammer out the bend. Continue hammering until the desired shape is reached or the piece has cooled to a dull red heat. Do not hammer without color!

11. Riveting with Heat (an alternative to cold riveting)

- a. Riveting can be done with or without heat but it is easier done with heat. The process is as follows:
 - 1) Place the rivet into a hole just slightly larger than the diameter of the rivet.
 - 2) With the two pieces of the work held firmly together, the rivet should stick out of the back side of the work by one and a half times the diameter of the rivet.
 - 3) Place the work, with the rivet head down, on the top of the anvil or over a heavy piece of steel.
 - 4) Heat the end of the rivet quickly with a torch or carbon arc to a dull cherry red color.
 - 5) Immediately strike the rivet with a sharp, heavy blow to upset the metal and spread the end. Use a single flat blow which should be ample to size and fix the rivet in place.

ACTIVITY:

1. Heat metal to different colors and shape it using the anvil, hammer, hardie, tongs, and gloves.
2. Take a piece of tool steel 7" long, heat it, and form it into a cold chisel.

Name _____

Date _____

Score _____

UNIT EXAM, METALWORKING

Multiple Choice, Answer the following questions with the most correct answer.

1. _____ The thickness of sheetmetal is measured by _____.
 - a. tenths of an inch
 - b. hundredths of an inch
 - c. thousandths of an inch
 - d. gauge

2. _____ Annealing means to
 - a. harden
 - b. soften
 - c. throw away
 - d. drill holes

3. _____ A scribe is a tool used for _____.
 - a. measuring
 - b. drilling
 - c. squaring corners
 - d. drawing lines on metal

4. _____ In hot metal work, upsetting means to _____.
 - a. shorten or thicken
 - b. heat and quench in water
 - c. heat and cool slowly
 - d. effects from distortion

5. _____ When selecting a rivet for length, how long should the rivet head stick out beyond the back surface of the metal?
 - a. Same as the diameter of the rivet.
 - b. One and a half times the diameter of the rivet.
 - c. Twice the diameter of the rivet.
 - d. 1/4"

- 6._____ Which of the following is NOT a common type of sheetmetal material?
- a. Aluminum
 - b. Mild steel
 - c. Stainless steel
 - d. Cast iron
- 7._____ In order to be considered cast iron the carbon content must be _____ percent.
- a. 2 – 6
 - b. 8 – 12
 - c. 14 – 20
 - d. 20 – 25
- 8._____ A tap is used to make _____ threads.
- a. male
 - b. female
- 9._____ A die is used to make _____ threads
- a. male
 - b. female
- 10._____ Which of the following type is NOT a thread size?
- a. Fine thread
 - b. Medium thread
 - c. Course thread
 - d. Machine thread
- 11._____ When riveting metal together you should use rivet made out of _____ material.
- a. the same
 - b. stronger
 - c. softer
 - d. none of the above
- 12._____ When drilling metal always use a _____ to make the center of the hole.
- a. cold chisel
 - b. chalk mark
 - c. center punch
 - d. pin punch

Short answer or fill in the blanks of the following questions.

13. The correct color for working metal hot when bending is _____.

14. The word that means the opposite of annealing is _____.

15. The correct color to indicate metal hardness if you want to make an ax or shear is _____.

16. List and describe the three different types of taps

1. _____

2. _____

3. _____

17. Are the threads on a bolt and a pipe the same? (yes/no)

18. What makes up the galvanized coating in metal (sheetmetal or pipe)? _____

19. Ductility refers to the ability of metal to be _____ without breaking.

20. How many square inches are there in a 4 foot by 8 foot sheet of sheetmetal?

Answer Sheet, Exam

1. D
2. B
3. D
4. A
5. B
6. D
7. A
8. B
9. A
10. B
11. A
12. C
13. Red or light orange color
14. Tempering
15. Dark Brown Color
16. Taper Tap, Plug Tap, Bottoming Tap
17. No
18. Zinc
19. Stretched
20. 4,608 sq/in

References:

Burke, Stanley R., & Wakeman, T. J. (1990). MODERN AGRICULTURAL MECHANICS (2nd ed.). Danville, IL: Interstate Publishers.

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Editors of Reader's Digest. (1973). COMPLETE DO-IT-YOURSELF MANUAL (7th ed.). Pleasantville, NY: Reader's Digest Association.

Special Materials and Equipment:

Scratch awls, metal snips, ball-peen hammers, hack saws, files, electric power hand drill, drill press, taps and dies, pedestal grinder, electric soldering iron. Graph paper, pencil, ruler, compass, small sheet metal piece, scribe. Layout tools, sheet metal working tools, two pieces of 24-28 gauge galvanized sheet metal for each student. Metalworking hand tools and power tools, a bench vise, various sizes of mild steel strap in different thicknesses from 1/4" to 1/2". A source of heat to heat and bend metal, preferably a gas fired forge; if not available, an oxyacetylene torch; blacksmith tongs, anvil. Select and have available for students ten common metalworking tools to see and handle. Provide several power tools for demonstration and student inspection also.

See Section 130Y for sheetmetal, hot and cold metal projects.

130L-1

FENCE CONSTRUCTION

AG 130-L

UNIT OBJECTIVE

After completion of this unit, students will understand basic farm and field fence construction and know the different applications for the different type of fencing.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Match terms associated with fence construction to their correct definitions.
2. Understand the different factors too consider when planning a fencing project.
3. Know the different types of temporary and permanent pasture fences.
4. Identify and understand the use of different tools used in fence construction.
5. Identify the different types of wire used in fence construction.
6. Know the steps in fence construction.
7. Know how the stretch woven wire and barbed wire.
8. Understand how to safely handle and use barbed wire.

A. Terms and Definitions

1. Line wires – Wires that run the length of the fence
2. Stay wires – Wires between the top and bottom wires
3. Suspension fences – Used for cross or boundary fencing on cattle ranges
4. Tension curve – Spring effect that is present in woven wire
5. Wire clip – Fastener used on steel posts
6. Fence staple – Fastener used on wooden posts
7. Wood preservative – product used to treat wood to increase the longevity of the wood
8. Movable fences – Intended to stay in one location for only a few weeks
9. Deadman – Usually a rock or tire buried underground to hold the fence down in low spots

B. Factors to consider when planning the location and arrangement of fences

1. Land Capability
2. Coordination of fields to cropping plans
3. Relation of fences to soil conservation practices
4. Placement justification of permanent and movable fences

a. Moveable fences

- 1) Welded wire panels used at the county fair.
- 2) Field fence wire on Tee posts to temporarily hold in sheep. Once the area is grazed off the sheep are moved to another area.

b. Permanent fences

- 1) Fences build for permanent pastures, corals, or yards not intended to be moved.
5. Arrangement of fields and passageways for convenience and labor savings
6. Building order of permanent fences

C. Types of livestock

1. Horses – Horses are mostly held in by fences with a combination of field fence wire on bottom and one or two strands of barbed wire on top.

2. Cattle – Cattle are usually held in by four or five strands of Barbed wire.
3. Sheep – Sheep are fenced in with field fence wire, sheep are smaller than cattle and can slip through a barbed wire fence.
4. Pigs – Pigs are usually raised in pens, but on pasture use field fence wire with at least one strand of barbed wire on the bottom to prevent them from pushing under.
5. Dogs – To keep dogs out of your pasture use a field fence wire with at least one strand of barbed wire on the bottom, same as you would to keep pigs in.

D. Types of Wire

1. Barbed Wire is fencing wire with sharp bards at regular intervals
2. Smooth Wire – a smooth wire, single or double strand, mostly used in electric fences.
3. Woven Wire – Commonly know as field fence wire, made by a weaving wire to form a mesh pattern. Mostly used in combination with barbed wire.
4. Placement of Wire – Always place the wire to the inside of the fence where livestock is being held. If livestock pushes on the fence the wire will be pushed against the post and not put any pressure on the fasteners.

E. Types of Posts

1. Wood Posts – Most common type used
 - a. Split Cedar – Posts made from cedar logs cut eight feet long and split into 1/4s.
 - b. Railroad Ties – Railroad ties make good solid fence posts. Mostly used in corals, end posts and corner braces.
 - c. Cedar 4' X 4's are used mainly on lawn fences and not on field fences
2. Steal Posts
 - a. Tee Posts – Metal posts with groves on one side to hold up the wire. Looking at the top of the post you will see the post has the shape of a T for strength.
 - b. Oil Pipe – Used oil pipe four inches in diameter, can be purchased at a cheap price and cut into lengths for fence posts. Entire corals have been made from oil pipe.

E. Steps in Fence Construction

1. Establish location

- a. Establish the line of the fence.
- b. Clear all brush and other obstacles.

2. Placement of the posts.

- a. Corner posts are the first posts to go in.
- b. Run a string or wire from corner post to corner post along the fence line, pull tight to ensure a straight line.
- c. Mark off the spaces for the holes to be dug or posts to be placed.
- d. Bury posts or drive them in place

3. Stretching Wire

- a. Once the corner posts are in place, end braces are in place and the posts are in place stretch the wire.
- b. Wire can be stretched by anchoring the stretchers or pullers to the bumper of a pick-up or to a tractor.
- c. Wire can be stretched by using a wench on the front or back of a pick-up.

4. Fastening wire to the posts

- a. At one end tie the wires off to the posts and stretch from the other end
- b. Once the wire is stretched tie the wire off at the end you are pulling from.
- c. To fasten wire to a wooden post, used a fence staple as illustrated on page 130L-5.
- d. To fasten wire to a metal post, use a metal clip as shown on page 130L-8.

References:

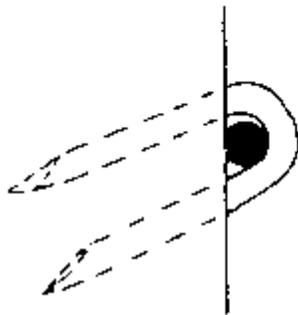
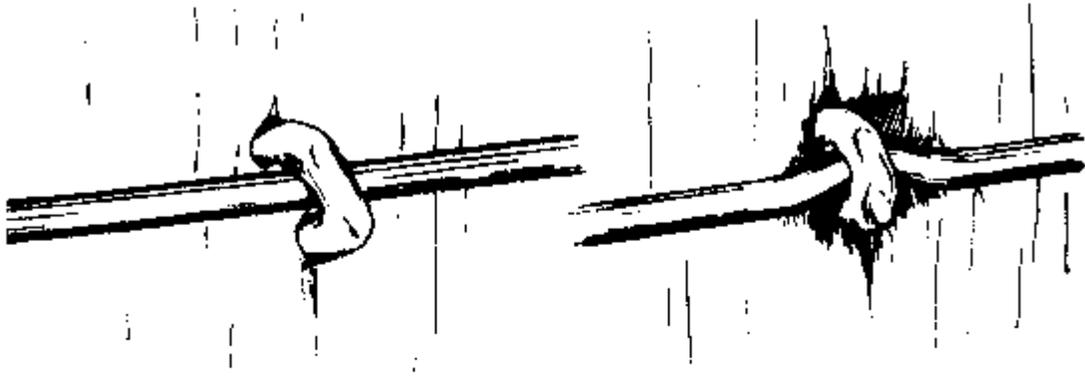
Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Phipps, Lloyd J., and Miller, Glen M.(1998) AGRISCIENCE MECHANICS. Danville, IL: Interstate Publishing

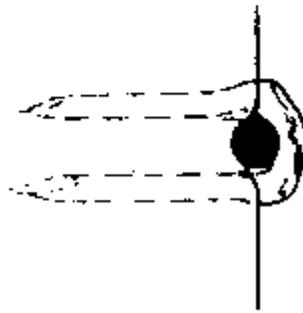
USE OF FENCE STAPLES

Driving the fence staples into far will weaken the wire.

Only drive the fence staple in far enough to hold the wire snug to the fence post



RIGHT WAY

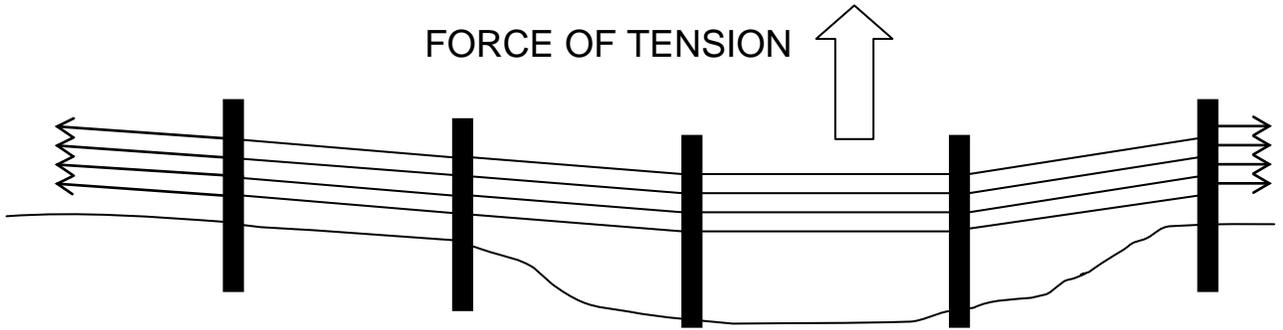


WRONG WAY

USE OF A DEADMAN

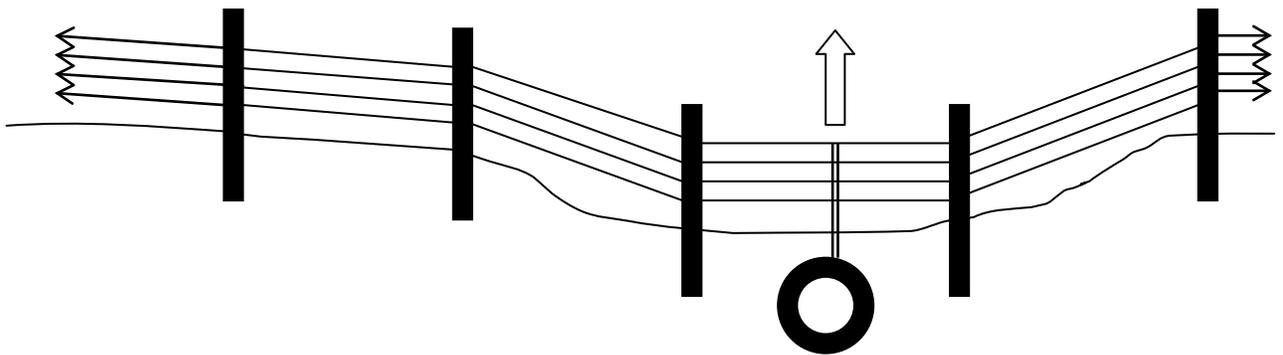
WITHOUT THE USE OF A DEADMAN

FORCE OF TENSION



WITH THE USE OF A DEADMAN

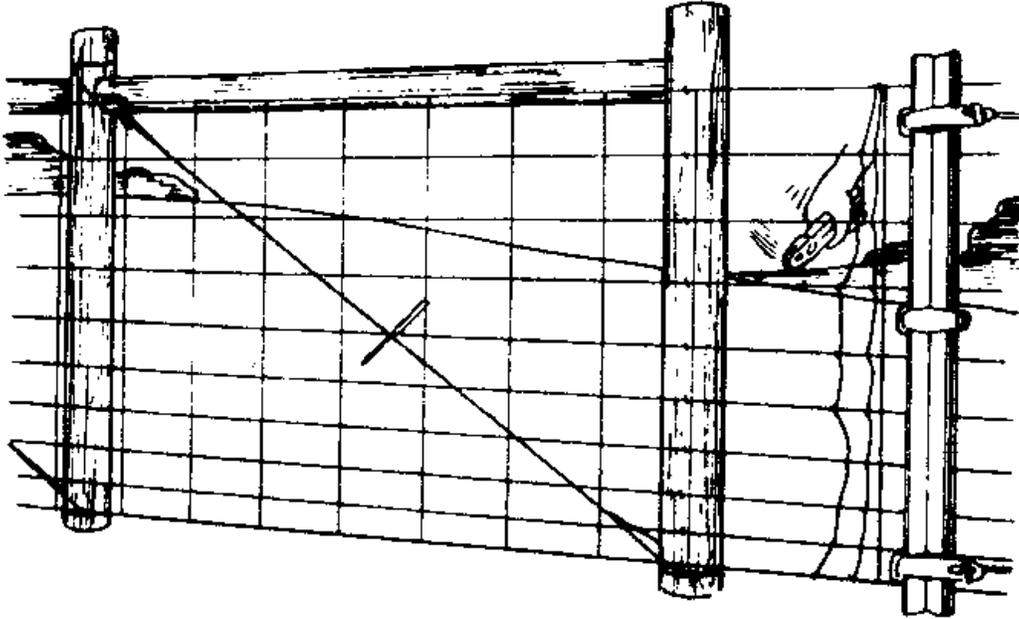
FORCE OF TENSION



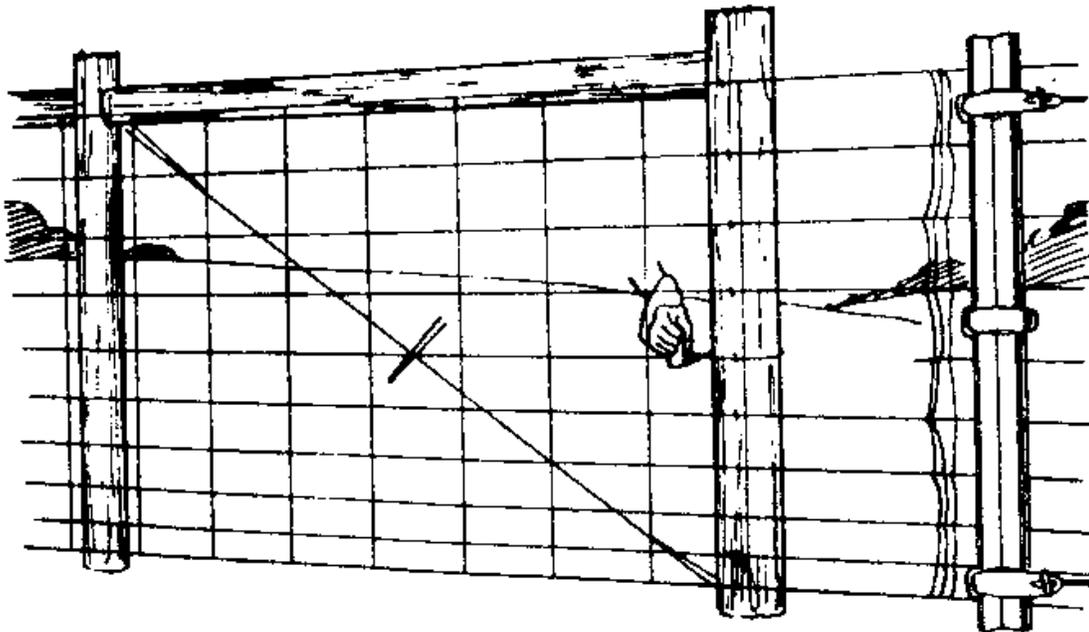
DEADMANS ARE USE IN LOW SPOTS OF THE FENCE LINE. WHEN THE WIRES ARE TIGHTENED THEY WILL TEND TO PULL THE FENCE UP, DEADMANS (usually a big rock or an old tire) ARE WIRED TO THE FENCE WIRES KEEPING THE FENCE ANCHORED DOWN.

TYING OFF FIELD FENCE TO THE END POST

1. Staple each line wire securely to the end post
2. Remove stay wires a sufficient distance to extend around end post and wrap back on itself



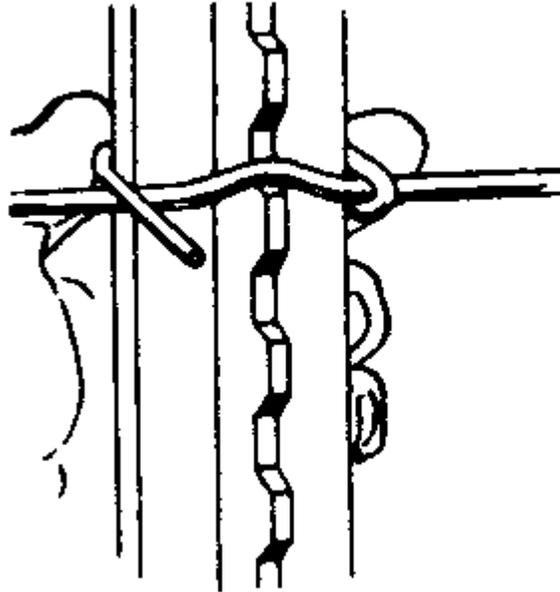
3. Cut middle line wire, extend around post, and wrap back on itself



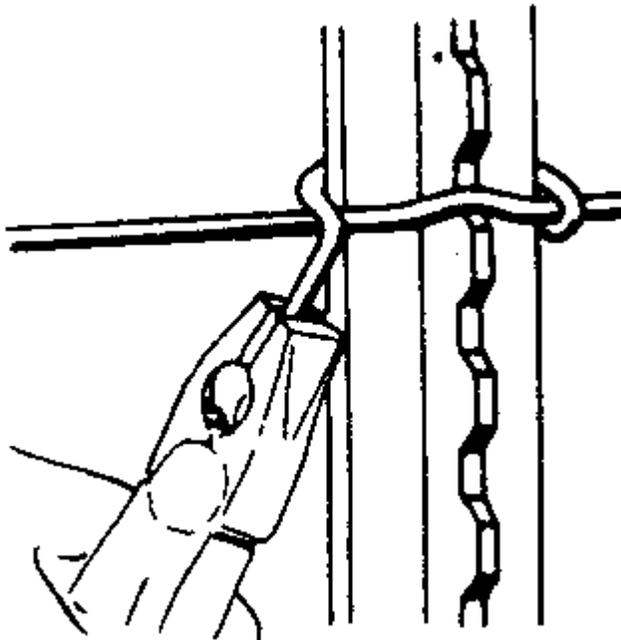
4. Repeat procedure with every other wire working toward top and bottom
5. Cut and wrap remaining wires leaving top wire until last

ATTACHING WIRE TO STEEL POSTS

1. Hook post clamp over line wire and snap into position around the post

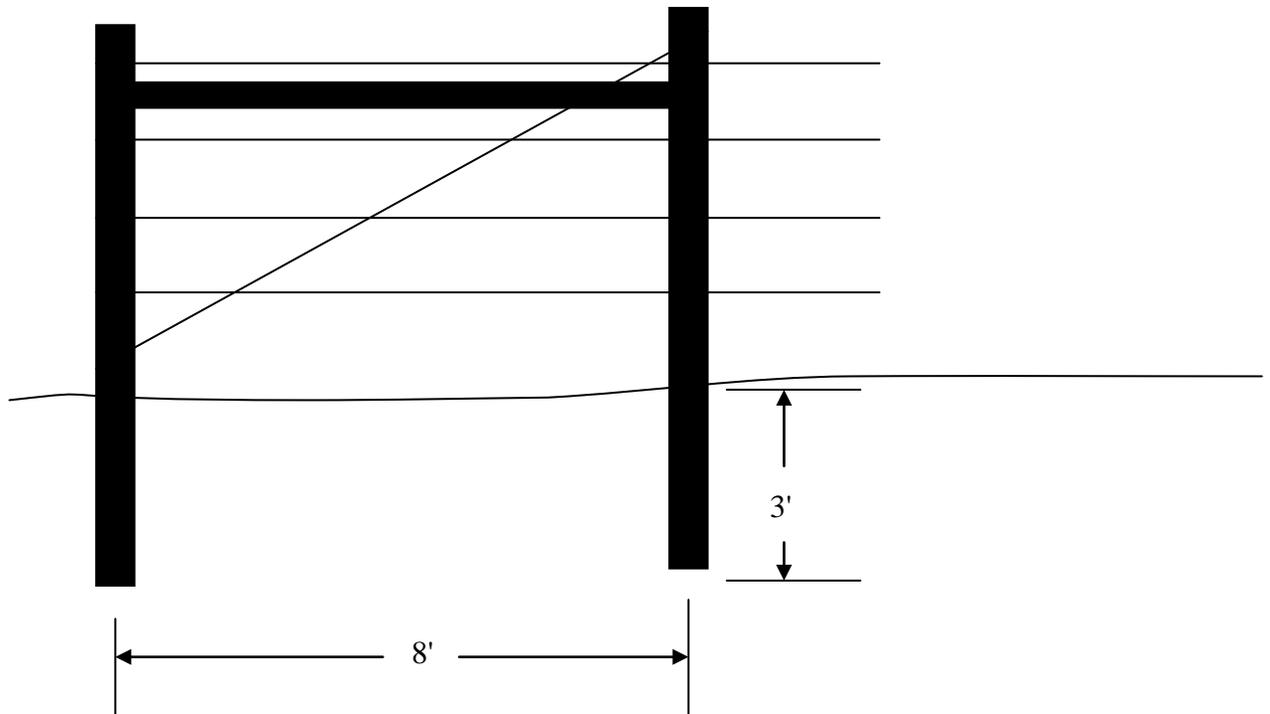


2. Bend other side over line wire to form hook



CONSTRUCTING AN END BRACE

1. Start with good solid posts 8' long, railroad ties make good end posts
2. Bury the posts 8' apart and use a 4" x 4" (or split cedar) as a cross member
3. Install a brace wire, bottom of the end post and the top of the other, if installed the other way around the fence will lose strength.
4. Twist the brace wire with a stick or a piece of pipe until tight



130M-1

CONCRETE AND MASONRY

AG 130-M

UNIT OBJECTIVE

After completion of this unit, students will be able to identify and list the ingredients and characteristics of concrete and calculate the amounts and costs of materials required for a particular application. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. List the ingredients and characteristics of concrete.
2. Calculate the amounts and costs of materials required for a particular application.
3. Build proper forms.
4. Mix, pour, reinforce, finish, and cure concrete.
5. Demonstrate the use of the basic tools needed to pour and finish a concrete slab.
6. Describe and use basic masonry techniques and tools.

CONCRETE PROPORTIONS

A. Mixture of Ingredients - Since part of the mixture can greatly affect the strength and durability of the concrete after it hardens, using the correct proportion of each part is critical.

1. Cement Paste

a. This is the mixture of cement and water that determines the concrete's strength; it varies according to water-cement ratio.

1) Water-Cement Ratio

- a) These are usually 5, 6, or 7 gallons of water to 1 sack of cement; the most common ratio is 6:1.
- b) This amount of water takes into account the water in the sand.

2) Cement comes in 94 pound sacks containing 1 cubic foot.

3) Sand has some water attached to its particles. This moisture needs to be estimated and an allowance made for it. The more moisture there is in the sand the less water needs to be added when mixing.

- a) Damp sand falls apart when squeezed into a ball. It contains about 1/4 gallon of water per cubic foot.
- b) Wet sand forms a ball when squeezed but leaves no noticeable moisture on the palm. This is the most usual kind and contains about 1/2 gallon of water per cubic foot.
- c) Very wet sand forms a ball when squeezed and leaves moisture on the palm. It contains about 3/4 gallon of water per cubic foot.

Note: To obtain a more durable concrete to withstand severe weather conditions and/or traffic, add less water.

2. Ratio of Cement: Fine Aggregate (Sand):Coarse Aggregate (Gravel)

a. Ratio is expressed as a three digit number called a mix, for example, 1:2:3.

130M-3

- 1) A 1:2:3 mix means one part cement, two parts sand, and three parts gravel.
- 2) The mix proportions can be based on either weight or volume.
 - a) A ratio of 1:2:3 can be stated 1 cu. ft. (sack) of cement, 2 cu. ft. of sand, and 3 cu. ft. of gravel.
 - b) It can also be 100 lb. (approximately a sack) of cement, 200 lbs. of sand, and 300 lbs. of gravel (1 cu. ft. of aggregate is approximately 100 lbs.).

b. A correct mixture assures that:

- 1) Each particle of sand and gravel is covered with cement paste.
 - 2) Each particle is bound to others when the cement paste dries and hardens.
- c. The intended use of the concrete also determines the ratio of the ingredients. Recommended ratios for mixing concrete for different types of uses can be found in charts in any basic book about concrete (consult references and resources listed).

3. Coarse Aggregate Size

- a. Should not exceed $\frac{1}{3}$ the slab thickness.
- b. Should not exceed $\frac{1}{5}$ the wall thickness.
- c. Maximum size is 1 $\frac{1}{2}$ inch with the most common being $\frac{3}{4}$ inch.

4. Mixture Yield

- a. Generally, the volume of mixed concrete will be about two-thirds the combined volume of the items used in the mix.
- b. Examples of how much material should be used to make 1 cubic yard of concrete can be found in charts in any basic book about concrete (consult references and resources listed).

5. Slump Test: slump is a rough measurement of concrete's consistency and workability.

- a. Common slumps used for most jobs are 3 - 4 inches. Slump should never exceed 6".

130M-4

b. The slump is determined by a test using a conical cylinder and a portion of the concrete batch to pour. The cylinder has a 4" diameter opening at the top and an 8" diameter opening at the bottom, and is 12" high. The test is performed as follows:

- 1) Place moistened cone-shaped container on a flat, level surface.
- 2) Fill the container 1/3 full with sample of concrete.
- 3) Rod this layer 25 times using jabbing strokes with a 5/8" solid steel rod - jabbing strokes as this helps to settle the concrete.
- 4) Add a second layer until the container is 2/3 full.
- 5) Rod this layer an additional 25 times.
- 6) Finally, fill the cone to the top edge and level it.
- 7) Rod a final 25 times. Remove any spilled concrete from around the base of the cone.
- 8) Lift the cone off the rodded batch within five seconds.
- 9) Without a retaining device the concrete will slump or fall from the original 12" height.
- 10) The difference in the original height and the final height is known as the slump.

ACTIVITY:

1. Using Supplemental Handout #1, have students complete an organic matter test and silt/clay test on their sand samples.
2. Determine moisture content of sand samples. Test different samples of different moisture ranges.
3. Using the information found in basic texts about concrete, solve problems on Supplemental Worksheet #1. More problems can be added if time permits. Use page 130M-47 as an overhead or handout on mixture ratios.

Supplemental Handout #1

TESTING A SAND SAMPLE FOR SILT AND CLAY

Procedure:

1. Fill a one-quart glass jar to a depth of 2 inches with the sand sample to be tested.
2. Add water until the jar is 3/4 full.
3. Screw on the lid and shake vigorously for one minute to mix all particles with water.
4. Shake the jar sideways several times to level the sand.
5. Place the jar where it will not be disturbed for 1 hour for a silt test or 12 hours for a clay and silt test.
6. After 1 hour, measure the thickness of the silt layer on top of the sand.
7. If the layer is more than 1/8 inch thick (more than 3% silt), the sand is not suitable for concrete unless the silt is removed by washing.
8. If the layer is not 1/8 inch thick in 1 hour, let the mixture stand for 12 hours. Then re-measure the layer(s) that have settled on the sand.
9. If the silt plus clay layer exceeds 1/8 inch, wash the sand before using it in concrete.

TESTING A SAND SAMPLE FOR ORGANIC MATTER

Procedure:

1. Place half a pint of clear drinking water in a clear glass quart-size jar.
2. Dissolve a heaping teaspoonful of regular household lye in the water.
3. Add half a pint of the sand sample to the solution.
4. Place a leak proof lid over the jar and shake it vigorously for a minute or more. (Be careful not to spill any of this solution since it is poisonous and highly injurious to the skin, clothes, and other materials.)
5. Let the sample stand for 24 hours.
6. The color of the liquid indicates whether the sand contains too much organic matter to be used in making concrete.

Clear solution - sand is clean and free of organic matter

Straw color (color of apple-cider vinegar) - presence of organic matter but can still be used to make concrete

Darker colored solution - indicates too much organic matter present to be used in making concrete

Name _____

Date _____

Score _____

Worksheet #1
CALCULATING PROPORTIONS

A concrete driveway is to be poured on a level surface. The slab will be 5 inches thick.

1. Specify the maximum size aggregate that should be used on the 5-inch slab.

_____ inch(es)

2. If one part cement, two parts sand, and three parts of gravel were used, how would it be expressed? Using chart provided on page 130M-47.

_____ : _____ : _____

3. With this ratio, how many sacks per cubic yard should be used?

_____ sks.

4. Using the same ratio, how much sand and gravel are needed to make one cubic yard of concrete?

_____ cu. ft. of sand and _____ cu. ft. of gravel

5. If a total of 10 cubic yards of concrete is needed, how much total cement, sand, and gravel should be mixed?

_____ sks. , _____ cu. ft. of sand, and _____ cu. ft. of gravel

ESTIMATING CONCRETE MATERIALS

A. Volume Estimation - The ability to estimate accurately is a very important skill, since an inaccurate estimate will cause the job to cost more than necessary and ingredients may be wasted. If insufficient material is ordered, the job must be stopped and then restarted with considerable increase in cost and time.

1. Area Calculation (For more information see Section 130C, Measuring)

a. Calculate the surface area in square feet that the structure will cover.

1) To get square footage of rectangular areas:

$$\text{Area} = \text{Length} \times \text{Width}$$

2) To find the area of a circle:

$$\text{Area} = 3.1416 (\pi) \times R^2 \text{ (Radius)}$$

3) To find the area of a triangle:

$$\text{Area} = 1/2 \times \text{Base} \times \text{Perpendicular Height}$$

2. Volume Calculation

a. Multiply the calculated surface area by the thickness in feet of the planned structure:

$$\text{Volume} = \text{Area} \times \text{Thickness (Depth)}$$

b. When calculating the volume of a long, narrow structure (for example, a building footing):

1) First find the cross-sectional area of the structure:

$$\text{Area} = \text{Width} \times \text{Depth}$$

2) Then multiply the cross-sectional area by the length of the structure.

c. The total volume of concrete required is expressed in cubic feet.

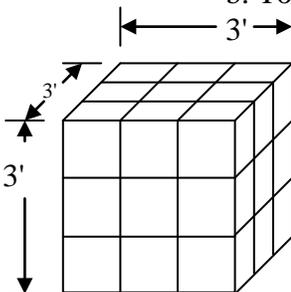
3. Unit Conversion

a. Concrete is calculated and sold by the cubic yard or the fractional quantities in quarters of a cubic yard.

b. To convert cubic feet to cubic yards:

$$\text{Volume (cubic yards)} = \text{Volume (cubic feet)} \text{ divided by } 27$$

(Page 130M-48)



4. Dry Bulk Materials

- a. If purchasing separate ingredients, use a chart found in basic texts about concrete (consult references and resources) to calculate the amounts of each item.
 - 1) Figure out the cubic yards needed for the project.
 - 2) Determine the recommended mixture for the project. (see page 130M-47)
 - 3) Determine the amount of each ingredient by multiplying the value off the chart by the cubic yards needed for the structure. For example, the amount of cement is calculated:
$$\begin{array}{rcc} \text{Chart Value} & \times & \text{Project Size} & = & \text{Cement Needed} \\ \text{(sacks/cu.yd.)} & & \text{(cu.yd.)} & & \text{(sacks)} \end{array}$$
- b. Cement is bought in whole sacks but separate ingredients can be purchased in increments of a 1/4 cubic yard.

B. Mix Ordering - Once the amount of concrete that is needed for a job has been calculated, a decision must be made about the on a method of mixing it. The deciding factors here are the amount of concrete needed, the time required to complete the job, economy, and convenience.

1. Site Mixed (mix-it-yourself):

- a. This method is for jobs that require less than a cubic yard.
- b. A 10% waste allowance should be added to the calculated amount of concrete needed.
- c. A clean storage area is needed for each ingredient: gravel, sand, and cement (must be kept dry).
- d. This is a very good method when pouring fence posts or small projects such as stepping-stones or walkways.
- e. This is the cheapest way to mix concrete.
- f. There are two methods for site mixing:

1) By Hand

- a) This method is used for very small jobs that require only a few cubic feet.
- b) Mixing is completed on a watertight, flat surface.
- c) Measure accurately and mix cement and sand thoroughly.

130M-9

- d) Add and mix gravel.
- e) Add measured quantity of water and mix until every particle has been covered with cement paste.
- f) Additional water might need to be added to obtain correct workability.

2) By Mixer

- a) This method is used when more than a few cubic feet of concrete are needed.
- b) Mixers can be rented from most rental agencies or possibly borrowed.
- c) The mixture is more uniformly and rapidly completed when done in a mixer
- d) Mixers are rated by batch size; do not exceed this amount.
- e) First load the mixer with all the aggregate and half the water; this is pre-measured for the batch size of the mixer.
- f) Start the mixer, add the sand, cement, and the remainder of the water.
- g) Allow the batch to continue mixing for at least three minutes, or until all the materials are thoroughly mixed.

2. Ready-Mix:

- a. This is the best method to use if the job calls for a cubic yard or more, or if time and convenience are important considerations.
- b. Additionally, this method is usually more economical when doing a large job.
- c. A 5% waste allowance should be added to the calculated volume of concrete needed.
- d. Usually the buyer must specify the maximum size of aggregate, minimum cement content, maximum slump, and load bearing capacity.
- e. Three Methods for Ordering Ready-Mix

1) Transit Mix

- a) This is the easiest and cheapest method to use when pouring three yards or more of concrete; less can be ordered but the cost increases.

130M-10

- b) The mix is delivered by truck to the exact location.
- c) It is consistent, well-mixed and prepared to specifications before delivery.
- d) The user needs no mixing equipment, no storage.
- e) Since trucks are so big and heavy, planning is needed to insure that the truck can reach the pour site.
- f) There are additional charges if the truck is not poured out in the 45 minute standby time.

2) Porta Mix (U-Cart, Trailer Mix)

- a) This is handled by most concrete batch plants and by some rental companies.
- b) It can be ordered in $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 cubic yard amounts.
- c) It is a very convenient method to pour small jobs around the home.
- d) The user needs no mixing equipment, no storage.
- e) It is consistent, well-mixed concrete; however, no specifications can be made.
- f) It is more expensive than other methods.
- g) The user needs a sturdy truck to pull the trailer.

3) Sack Mix (Sackrete)

- a) This comes in 90-pound sacks containing the right amounts of cement, sand, and gravel.
- b) The user just adds water and mixes; one sack makes around $\frac{2}{3}$ of a cubic foot.
- c) This method is ideal for small jobs, for example, fence posts; the user needs to have a mixer or must hand mix.
- d) It is quite expensive, approximately four times as much as other methods.

ACTIVITY:

1. Locate different concrete structures around the school. Measure the dimensions of the structures and use these measurements to calculate the volume of concrete that was needed to build the structure.
2. Assign each student a company which deals with either transit mix, cart mix, bulk materials, or sack mix to call and find out current prices.
3. Have students complete supplemental worksheet #2. Add some problems of your own.

Name _____

Date _____

Score _____

Supplemental Worksheet #2

Estimating Concrete Quantities

I. A concrete slab for a steel building is to be poured on a level surface. The dimensions of the slab are: length 40 feet, width 30 feet, and thickness 6 inches. The concrete is to be ordered from a batch (ready-mix) plant. Remember to allow for uneven surface of the dirt base

SHOW ALL WORK!

1. How many cubic feet of concrete are needed? _____

2. How many cubic yards of concrete are needed? _____

3. How much concrete should be ordered from the plant? _____
(Remember to round off answer up to the nearest 1/4 cubic yard.)

4. What is the total cost to complete the job? _____
Make sure to add tax! (Idaho tax is 5%)

II. A concrete walkway is needed along the side of a home. The dimensions of the walk are: width 2 feet, length 20 feet, and thickness 3 inches. The concrete will be site-mixed using a borrowed mixer. The walk will be poured in 4 foot long sections for ease of repair in case of uprooting by the neighbor's tree. Remember to allow for an uneven leveling job done by your assistant.

SHOW ALL WORK!

1. Calculate the total cubic feet of the walkway. _____

2. How many cubic yards does the walkway measure? _____
Remember to take into account the uneven soil surface.

3. The recommended mix is 1 : 2 : 2 1/4 using 3/4 inch maximum aggregate.
 - a. How many sacks (cubic feet) of cement are _____
needed to complete the job? (Round off answer to whole sacks.)

How much would this amount of cement cost? _____
(Remember to include sales tax.)

 - b. How many cubic feet of sand are needed? _____

 - c. How many cubic feet of gravel are needed? _____

Note: Current prices of materials are needed to make this worksheet complete and accurate.

FORM PREPARATION AND REINFORCEMENT

A. SITE PREPARATION

1. Selection of Site
2. Lot lines are located and checked!
 - a. This provides protection for the owner.
 - b. The lines must be completed by a registered engineer or licensed surveyor.
3. Clearing and Rough Excavation of Area
 - a. The site should be cleaned of all debris and refuse.
 - b. Where no grading is needed, the site can be laid out and batter boards erected.
 - c. If the site is on a steep slope or rugged terrain, rough grading must be completed before laying out building lines.
 - d. Topsoil should be removed and stock piled where it will not interfere with the construction. Later it will be used for the finished grade.
4. Laying Out Building Lines
 - a. It is best to establish lines using a leveling instrument.
 - b. Lines can, however, be taken off lot markers.
 - 1) It is important that distances be perpendicular to existing lines and that building lines be square.
 - a) To establish a right angle, use the 3-4-5 method based on the Pythagorean theorem.
 - b) Locate corners formed by the intersection of the outside wall surface.
 - c) Drive stakes into the ground and then set tacks in the tops at the exact spot for the corner.
 - c. After lines have been set up, check them carefully.
 - 1) Measure the lengths and widths.
 - 2) Measure the diagonals which should be equal.
 - 3) An out-of-square foundation can cause continuous problems and frustrations throughout construction.

5. Batter Boards

- a. They are set up around the building layout stakes.
- b. Their purpose is to preserve the building lines after layout stakes have been removed because of necessary excavation for footings and foundations.
- c. Locate them about 4 feet beyond the building lines where excavation work will not disturb them.
- d. To Make Batter Boards:

- 1) Use 2 x 4's for the stakes and 1 X 6's for the ledger boards.
- 2) Drive in stakes to desired depth.
- 3) Nail ledger boards to the stakes, making sure they are level and at a good working height slightly above the top of the foundation.
- 4) All the batter boards should be level with each other.
- 5) Ledger boards should be long enough to extend past each corner.

- e. To Establish New String Lines:

- 1) Pull the two strings so they pass directly over the layout stakes, then use a plumb bob to line up the strings directly over the tack.
- 2) Mark the top of the ledger boards where the string lines cross and then make a shallow saw kerf at the mark.
- 3) Pull the string lines tight and fasten them to nails driven in the back of the ledger boards.
- 4) Make sure the lines are set in the saw kerf.

6. Final Excavation:

- a. Remove lines from batter boards when completing excavation work.
- b. The highest elevation on the perimeter of the excavation is the control point for establishment of the depth of excavation and the height of the foundation.
 - 1) Foundations should extend about 8 inches above the finished grade so the wood finish and framing members will be protected from soil moisture.
 - 2) The finished grade should be sloped so surface water will run away from the foundation.

3) It is important that the foundation be located below the frost line so no damage is incurred when the soil freezes.

c. The depth of the excavation may be limited by the overall levelness of the site, slope to the street, curb or existing concrete foundation height, and the elevation of the drainage or sewer lines.

B. Preparation of Forms

1. Definitions

a. A form is a metal or wooden structure that confines the concrete to the desired shape or form until it sets or hardens enough to stand by itself.

b. A footing is a concrete base that provides a solid, level foundation for concrete, brick, or block walls.

1) Because the footer is wider than the wall, it spreads the building weight over a wider area.

a) The common practice is to make the footing the same height and twice as wide as the thickness of the wall it supports (on good load-bearing soil), ie., a 4" thick wall would have a footing at least 4" high and 8" wide.

b) Footing must be placed below the frost line in order to prevent structural damage.

c) The footing should be placed on all rock or all soil and not a part of each; this prevents uneven settling.

2. Form and Footing Construction

a. Form boards are temporarily nailed to stakes and to each other.

1) Duplex head nails are used to help in form removal.

2) In order to allow nail removal, always nail through the stake into the form board; never nail from the inside.

3) Be sure the stakes do NOT stick up above the top of forms as this will greatly affect the finished work; saw stakes off flush with the form.

130M-16

- 4) Coat form boards with form oil or diesel fuel since this prevents sticking to the concrete and allows easy removal.

b. Footing Forms:

- 1) After excavation is complete, replace lines on batter boards and locate corners again with plumb bob. Drive stakes to mark points, making sure they are level with top of footing.
- 2) Drive a set of grade stakes along the footing line; use a builder's level to keep all the stakes level with the top of the footing.
- 3) Construct outside forms first, making their tops level with the grade stakes.
 - a) After the outside boards are in place it is relatively easy to set the inside sections.
 - b) Use 3/4 inch plywood or 1 inch lumber for form boards, held in place with metal or 2 X 4 wood stakes every 2 to 3 feet.
- 4) Use spreader boards to maintain the correct width for the footing; usually 1 X 2's are satisfactory.
- 5) The top of the footing must be level!

c. Wall Forms:

- 1) Use 3/4 inch tongue and groove lumber or plywood for side forms nailed to 2 X 4 studs every 2 feet.
- 2) Forms must be strong and well braced to withstand the side pressure created by the heavy, wet concrete.
 - a) This pressure increases as the height of the wall is increased.
 - b) Wall ties (tie rods) are used to prevent the sides from spreading outward or warping inward.

These combine the features of old wood spreaders and wire ties. Many different manufactured devices are available.

d. Slab-On-Ground Forms:

130M-17

- 1) Concrete is laid directly on ground such as a driveway, sidewalk, or slab floor.
 - a) Soil must be firm and compact, disturbed as little as possible.
 - b) On poorly drained soils, lay a 4"-6" subbase of gravel or crushed rock and compact it.
 - c) A vapor barrier is essential under every section of a slab floor.

This prevents the movement of water from ground into the slab and vice-versa. Common materials used to create a vapor barrier are 4-mil polyethylene film, 55 lb. roll roofing, or asphalt-impregnated kraft paper.

- 2) Forms are constructed out of 2" thick wood material.
 - a) 2 X 4's are used for walks.
 - b) 2 X 6's are used for drives and floors.
 - c) Support the forms by using metal or 2 X 4 wood stakes every 3 feet.
 - d) Use soft, clean, straight lumber.
 - e) 1" thick wood material can be substituted for small pours; however, it needs to be supported every 2 feet.
 - f) A slope should be included for all slab construction in order to carry off surface water. A slope between 1/8 to 1/4 inch per foot is adequate.

C. Concrete Reinforcement

1. What is reinforced concrete?

- a. It is concrete which has either steel reinforcing rods or wire mesh embedded into it when it is poured.

- 1) Reinforcement bars (rebars) are used in thicker pours such as foundation footings and building columns.

- a) They are made of steel and have a rough surface to prevent slipping when embedded.

130M-18

- b) Bars are classified by a number system corresponding to the diameter in eighths of an inch, i.e., # 4 rebars are 4/8" (which reduces to 1/2"). (They are available in diameters from 1/4" to 1" and over.)
- c) Rebars are purchased in 20, 40, and 60 ft. lengths.
- d) Bars can be joined by lapping over ends and wiring together or by welding. (The general practice is to lap bars by 24 times the diameter, i.e., 1/2" rebars should be lapped $24 \times 1/2 = 12$ inches.)
- e) For most applications, the bars should be placed 1 1/2" from all surfaces; however, 3/4" is allowed at times. (Rods must be kept off the surface of the base material as this will cause rusting.)
- f) Bars are run vertically in walls and horizontally in footings. In thick slabs, they can be placed in a cross-sectional pattern.

2) Concrete slabs are generally reinforced using wire mesh.

- a) The mesh is steel wire welded to form a cross-sectional pattern. (The sizes are 6, 8, and 10 gauge wire.) (Generally a 6-by-6 inch mesh pattern is used.)
- b) Mesh should be rolled out and flattened, then placed inside the forms.
- c) It can be purchased in different widths and then wired together to form longer or wider pieces. (Different pieces should be overlapped by at least one and a half squares and wired securely.)
- d) It should be located from 1 - 1 1/2 inch below the top surface, approximately in the center of the slab. (Mesh MUST be kept off the base material so some support might be needed. This is to prevent the wire rusting inside the concrete.) (As the concrete is being poured, a steel hook is used to pull the mesh up to the desired height. Small concrete blocks can be used to hold the mesh in place during the pour)

2. Why reinforce concrete?
 - a. Reinforcement increases the strength of the concrete without adding extra thickness which would add greatly to the cost of the job.
 - b. Reinforcement prevents cracking under stress of floors or driveways where heavy equipment and machinery are used.
 - c. All concrete columns and structures must be reinforced with steel in order to withstand normal stresses.
 - d. On large complicated jobs, consult local construction engineers or concrete contractors regarding the size and amount of steel to use and how it should be placed.

ACTIVITY:

1. Go on a short field trip to a construction site (commercial or residential) and can observe how sites are prepared, forms are constructed, and reinforcement is used. Quiz students on what they observed.
2. Plan a concrete project at the school and have students complete the necessary steps to prepare the site, construct forms, and include the necessary reinforcement. This activity could be worked on throughout this lesson. Coordinate this activity with the next lesson, Placing, Finishing, and Curing concrete.
3. Go out to the athletic fields and practice laying out corner stakes using the 3-4-5 method and the diagonal method. Set up teams of 3-4 students each. (See Section 130-U, Surveying)

PLACING, FINISHING, AND CURING CONCRETE

A Placing (pouring)

1. Pre-pour Guidelines

- a. Place concrete as close to its final position as possible. Get truck or wheelbarrow as close as possible.
- b. Place concrete in the forms as soon as possible, because concrete starts to harden about 15 minutes after it is mixed; in no case wait more than 45 minutes. Ready-mix companies charge a standby time if the truck is not emptied after 45 minutes.
- c. Before pouring, wet down the base material to prevent the water in the concrete from being drawn into the dry base material. Water loss will weaken the concrete.
- d. Check the forms for the last time with a carpenter's level.
- e. Have all tools at hand and a helper or two.

2. Tools and Equipment

- a. A square point shovel is used to move material and to fill in corners and low spots.
- b. A wheelbarrow is used to move material where the truck and chute cannot reach.

3. Pouring and Spreading

- a. Start placing concrete in a corner and work away from it.
- b. Use a shovel to spread concrete. Do not use a garden rake or hoe because they separate the coarse aggregate.
- c. Dump each succeeding load against the previous one; do not dump in separate piles and rake them together.
- d. The level of concrete should be higher than the forms. This will allow for settling, tamping, and screeding.
- e. Concrete should not be dropped from a large height or thrown to far with a shovel.

B. Tamping

1. Process

- a. Tamping is a means of pushing the coarse aggregate down from the surface and bringing the fine aggregate to the top.

130M-21

- b. Be careful not to tamp too much!
- c. At this time, run a shovel along the inside of the forms; this will help to push back the coarse aggregates from the edges.
- d. Use a hammer to tap along the forms to help vibrate the fine aggregates to the outside surface and fill in the voids.

2. Tools and Equipment

- a. Hand Tamp (Turkey's Foot) - This is a hand-held device made with a rectangular piece of expanded metal which is operated while standing in the wet concrete. The expanded metal is sized to push down the coarse aggregates and allow the fine aggregate to come up.
- b. Roller Tamp (Jitterbug) - This device has two rollers made of expanded metal; as it is rolled across the surface the gravel is pushed down. The roller type is operated from the outside edge of the slab and comes with extension handles to reach across larger distances.

C. Screeding (striking off)

1. Process

- a. Screeding removes the excess concrete and fills in low spots.
- b. Bring the surface of the concrete even with the top edge of the form.
- c. Place a board across the edges of the form, and move it back and forth in a sawing motion. It is slowly advanced along the slab.
- d. Make sure there is a surplus of concrete against the front face of the screed board to fill in low spots.

2. Tools and Equipment

- a. Screed Board (Straight Edge) - a straight 2 X 4 or 2 X 6 plank (NOTE: It is recommended that this be purchased the morning of the pour in order to insure a straight (unwarped) piece of lumber.
- b. Power Screed - a device that strikes off and compacts the concrete which is used for large pours

D. Floating

1. Process

- a. The floating process brings the fine aggregates and cement paste (cream) to the surface which allows for further finishing.
- b. It also embeds the coarse aggregates just below the surface.
- c. Additionally, it aids in leveling ridges and filling voids left by the screed board.
- d. A hand float is used by holding it flat on the surface and swinging it in a sweeping arc; very light pressure is applied.
- e. Bull floats are pushed and pulled across the surface.
- f. Avoid overworking the concrete while it is soft since this may bring excess water to the surface.

2. Tools and Equipment

- a. Concrete Float - made of wood, aluminum, or magnesium. It consists of a flat rectangular base of wood or metal with a handle attached; the edges of the base are chamfered. Hand floats are used mostly for small jobs and outside edges.
- b. Bull Float - consists of a rectangular wooden board (or lightweight aluminum plate) for a base approximately 3-4 feet long. A swivel pole handle is attached to the base. It comes with extension handles to reach across larger slabs and is operated while standing around the edge of the slab. (NOTE: The following finishing procedures should be completed after the water sheen has disappeared from the surface and the concrete has stiffened slightly.

E. Edging

1. Process

- a. Rounds the corners of concrete in the form.
- b. Prevents edges from chipping off.

2. Tools and Equipment

- a. Concrete Edger - The blade is made of flat sheet steel with a 3/8" edge turned down along the long side to form a rounded corner. The ends are turned up slightly. Some are equipped with handle attachments so they can be used on large pours.

F. Jointing

1. Process

- a. By cutting grooves or placing joints in the slab, the location of cracks can be controlled.
 - 1) A planned break permits the concrete to expand and contract without cracking.
 - 2) If cracks do occur with grooves, it will usually happen below the surface under the groove.
- b. Control joints are needed every 4 to 5 feet apart in sidewalks.
- c. Joints are needed 10 to 15 feet apart for floors, drives, or patios.
- d. Cut a joint down the center of 10 foot and longer slabs.
- e. The depth of the grooves should be at least $\frac{1}{5}$ of the thickness of the concrete.

2. Tools and Equipment

- a. Joint Material - The joint can be created using a $\frac{3}{8}$ " softwood board, $\frac{1}{2}$ " asphalt strip, or by pouring sections at different times and using a compound to prevent the sections from sticking together.
- b. Groover - The bottom blade is flat with a raised ridge down the center that is $\frac{1}{2}$ inch wide and comes in different depths. The base is fabricated of cast or sheet steel. Some type of straight edge must be used.
- c. Power Saw with Masonry Blade - used to create grooves in slabs, usually on large jobs. It cannot be done until 18-24 hours after concrete is poured.

G. Finishes

1. What type of surface is needed?

Consideration:

- a. Slab uses
- b. Interior or exterior
- c. Non-slip or smooth
- d. Sealed for sanitary reasons
- e. Water washing
- f. Decorative

2. Popular Surfaces

a. Floating - The surface should be floated a second time after the concrete has been set so the water and fine material will not be worked to the top.

- 1) It is done with a wood or metal float. Wood floats produce a rougher finish than metal floats.
- 2) Floating gives a medium non-slip surface, good for concrete which is constantly exposed to outside weather and meant for general use.
- 3) This floating procedure is usually completed before doing another surface finish such as troweling.

b. Brooming is used if a rougher finish is required than floating.

- 1) It is done after the second floating operation.
- 2) A damp, stiff-bristled (coarse-straw) broom is pulled lightly across the surface of the concrete.
- 3) This gives a rough surface, provides excellent footing and traction; it is especially good for outside areas which become slick from rainy weather or where there is constant use of water such as in a milking barn.
- 4) For a finer texture, steel trowel the surface first and then use a soft-bristled broom.

c. Troweling produces a smooth, hard surface since this action brings the cement paste to the surface.

- 1) It is done immediately after floating when the surface is semi-hard.
- 2) A troweled surface allows for easy cleanup and is ideal for sanitary conditions; however, it is extremely slippery when wet.
- 3) It is completed with a steel hand trowel which is a rectangular piece of sheet metal with a handle attached.
 - a) For the first troweling, hold the trowel flat against the surface, making sweeping arcs back and forth with even pressure.
 - b) For the second troweling tilt the leading edge of the trowel upward. This step should be done when a hand pressed against the surface leaves only a slight impression.

- 4) This process can also be completed with a power troweler which produces a similar surface to the hand trowel and is excellent for large jobs. To operate the power troweler, the concrete must be hard enough to stand on.
- 5) Additional trowelings will make the surface smoother and harder. However, excessive troweling will leave the surface weak and easily damaged by frost and chemicals.

H. Curing

1. Guidelines

- a. To cure properly, the concrete must be protected from drying air, excessive heat, and freezing temperatures for several days after pouring.
 - 1) Preventing the moisture loss during the early stages of hardening (hydration) is extremely important.
 - 2) Hot, dry weather can cause the water to evaporate too rapidly, so the concrete will not set properly.
 - 3) Extreme cold can cause the water to freeze and expand the concrete. (Special air entraining chemicals can be added to concrete for cold pours. The chemicals create small bubbles which allow the concrete to expand and contract without cracking.)
- b. Concrete must be kept moist and warm while it is setting (hardening).
 - 1) Concrete should dry slowly.
 - 2) This will greatly increase the strength and durability and will prevent the failure (cracking, crumbling, or breaking) of the concrete before the end of its expected lifetime.
- c. Curing time varies from 5 days (warm weather) to 7 days (cold weather), with 6 days being a satisfactory average.
 - 1) Concrete kept moist for seven days is about 50% stronger than concrete which is allowed to dry during the same time.

2) If moisture is maintained for one month, the concrete is double the strength of that which is allowed to dry immediately.

d. Form boards should remain in place as long as possible; if feasible, they should remain until the curing is completed.

2. Different Methods of Curing Concrete

- a. Seal the surface by covering it with plastic sheeting or waterproof paper; joints must be sealed and covering must lay flat and be anchored at the edges.
- b. Cover the concrete with burlap, canvas, sawdust, straw, sand, or another type of insulating material. This covering must be kept continuously wet during the curing time.
- c. Keep the concrete constantly moist with a lawn sprinkler or a soaker hose.
- d. Spray the concrete with a plastic-based curing compound that forms a continuous membrane over the surface. It is essential the coverage be complete.

ACTIVITY:

1. Bring students to a construction site where concrete is being poured. This could be coordinated with Activity #1 from the last lesson.
2. Continuation of Activity #2 from the last lesson: demonstration of placing, finishing, and curing can be completed. If necessary, mixing can also be included (Supplementary Handout #2 was included to help with site mixing, next page).
3. Complete a slump test on the concrete to be poured. Follow the guidelines presented earlier in this section, Concrete Proportions.
4. Set up small concrete projects (half-pint milk cartons) which can be used to demonstrate the effects of reinforcement, mixing, temperature, and curing on concrete strength. A small testing unit using a hydraulic press or jack can be built so some quality destructive testing can be performed. Remember to keep safety in mind!

Supplemental Handout #2 - Mixing Concrete

A. Which method should you use to mix concrete?

1. Site Mixing (by hand or mixer)

- a. All ingredients need to be present.
- b. To measure ingredients, construct a cubic foot measuring box or obtain a metal bucket that has been marked to show one cubic foot.
- c. Another option is to measure ingredients using shovelfuls; on the average there are 10 shovelfuls per cubic foot. This can vary according to individual and size of shovel. This method is recommended only for individuals who have experience using shovelfuls.

2. Using a Portable Mixer

- a. With mixer stopped, add in all coarse aggregate and half the water. (The mixer's capacity (batch size) is approximately 60% of its total volume.) (Never exceed the batch size of the mixer.)
- b. Start the mixer, and then add sand, cement, and the rest of the water.
- c. Continue to mix for three minutes or until materials are thoroughly mixed and the concrete is a uniform color.
- d. Place batch into wheelbarrow and move to pour site.
- e. Wash out the drum after each batch; scour at the end of the day adding water and several shovelfuls of coarse aggregate while turning; rinse it out and then dry.

3. Mixing by Hand

- a. Measure out ingredients.
- b. Spread sand in a ring on the mixing area, add cement, and mix until there is a uniform color without streaks. Add coarse aggregate and turn the mix over three times.
- c. Form a depression in the middle of the heap, add some pre-measured water, and work it into the center of the mixture. Add more water as needed and mix until the entire pile is damp.
- d. Shovel the dry part of the mix into the depression until the water has been absorbed. Be careful not to let the walls collapse on the ring. Then turn the whole heap over until it is evenly moist.

130M-28

- e. Form a new depression if there is a need to add more water. If only a little water remains to be added, sprinkle it on the surface of the heap. Never change the ratio of cement and aggregate.
- f. To test the mix, draw the shovel backward over the heap in a series of jabs; try to leave clear cut ridges. If mix is too dry, they will be indistinct; if too wet, they will level out.
- g. Shovel batch into wheelbarrow and move to pour site.
- h. Clean up by scouring the mixing area and equipment.

LAYING MASONRY UNITS

A. Masonry is anything constructed of stone, brick, tile, or concrete blocks, usually with the use of mortar or cement as a bonding agent.

1. Terminology

- a. Masonry Units - Brick, stone, tile, or concrete block which are laid in courses with mortar joints.
- b. Brick - Solid, rectangular-shaped units which are created by kiln-baking various clay and shale mixtures; they can vary in colors and hardnesses but are of uniform size. In the U.S., bricks measure 2 1/4" by 3 3/4" by 8."
- c. Tile - Hollow rectangular units made from burning clay and shale. The shape is created by forcing the pliable clay mixture through a molding die. The widths and thickness differ depending on the style of tile; however, the length is always a standard 12."
- d. Stone - There are six kinds of natural stone construction: granite, marble, slate, limestone, sandstone, and bluestone. Stone can be purchased in three finishes: dressed, semi-dressed, and undressed. The shapes and dimensions vary according to the stone and finish used.
- e. Concrete Block - Ready-made, pre-cast units made from portland cement and fine aggregates such as sand, pebbles, crushed rock, or cinders. The concrete mixture is then forced into a mold of the desired shape.
- f. Mortar - A mixture consisting of portland cement, hydrated lime, sand, and water. This is what holds the units together
- g. Laying Block - The process of mixing mortar, applying it to block, and placing the block to create walls.
- h. Courses - the layers of the masonry units
- i. Mortar Bed - A layer of mortar on which the masonry units are laid.

2. Tools

- a. Brick Trowel - used by the mason in laying units and when working with mortar. It is pointed and measures 4 3/4" by 11."
- b. Mortar Board - wooden board used to hold mortar near the work site.
- c. Jointing Tool - used to tool mortar joints; compresses mortar, and makes joint watertight. It comes in different shapes.

130M-30

- d. Carpenter's Level - a device used to ensure that courses are plumb and level
- e. Builder's Line - used to ensure that courses are straight
- f. Mason's Hammer - a specialized hammer used to cut masonry units to desired sizes
- g. Star Drill - a specialized hand drill used to drive holes in masonry and concrete. The drill point is temper hardened and looks somewhat like a four-point star; the shank is made of high-grade carbon steel. It is operated by striking with a hammer.
- h. Carbide-Tipped Masonry Drill - a specialized power drill used for drilling holes in masonry and concrete. The tip is treated with tungsten-carbide to resist heat and wear.

NOTE: All of the following information refers only to the installation of concrete blocks; however, the installation of brick, tile, and stone is very similar.

B. Types of Blocks

1. Standard Dimensions:

- a. Length - 15 5/8 inches
- b. Height - 7 5/8 inches or 3 5/8 inches
- c. Width - 7 7/8, 3 5/8, 5 5/8, 9 5/8, or 11 5/8 inches
- d. When laid with a 3/8-inch mortar joint, the block's overall dimensions are 8" by 8" by 16" (7 5/8 X 7 5/8 X 15 5/8).

2. Block Style

- a. Hollow or Solid - Hollow spaces are called cores; a solid unit has a core area of 25% or less of the total cross-sectional area.
- b. Heavyweight or Lightweight - Heavyweight units weigh approximately 40-50 lbs. while the lightweight units weigh approximately 25-35 lbs. The difference in weight is due to the different types of aggregates used in manufacture.

3. Block Shapes

- a. Stretcher - This is the most commonly used block for straight wall runs; it has slight extensions called ears on each end which form a core when laid end to end. (2 or 3 core)
- b. Corner - same as a stretcher except that one end is smooth; it is used at the end or corner of a wall.

130M-31

- c. Half Block - both ends are smooth; it is used for openings and ends of walls.
- d. Sash or Jamb - have special grooves for the installation of windows or doors.
- e. Miscellaneous - solid top, partition, bull nose, half-height, lintel; each has a special application.

C. Job Estimation

1. How many blocks?

- a. To estimate the number of blocks (8 X 8 X 16) needed for a wall, use this formula:

1) Height of Wall X $1\frac{1}{2}$ = Number of Courses (A)

- a) One foot (12 inches) is $\frac{12}{8}$ or $\frac{3}{2}$ or $1\frac{1}{2}$ of the height of a block.
- b) The height can then be multiplied by $1\frac{1}{2}$ to determine the number of courses needed.

2) Length of Wall X $\frac{3}{4}$ = Number of Blocks per Course (B)

- a) One foot is $\frac{3}{4}$ the length of one block.
- b) Therefore, the length of the wall in feet can be multiplied by $\frac{3}{4}$ which gives the number of blocks needed for one row.

3) A X B = Total Number of Blocks (for 1 wall)

- b. When planning a project, it is important that the dimensions between corners and all openings utilize full- or half-length block; this will save time and money and improve the overall appearance of the project.

2. How much mortar?

- a. Purchase approximately $2\frac{1}{2}$ bags of masonry cement and 667 lbs. of mortar sand for each 100 blocks.

ACTIVITY:

1. Have students complete homework assignment which entails writing down all the uses of masonry construction around their home.
2. Take students on a short field trip around the school and have them identify the masonry construction used.
3. Plan out a site where some masonry construction is needed around the department or school.

D. Footing Construction

1. Footing or Footer

- a. This is a continuous slab of concrete which provides a solid, level foundation for block or brick.
 - 1) It should be at least as deep as the wall is wide (i.e., 8" wide wall should rest on a footer that is at least 8" deep).
 - 2) The footer width should be at least twice that of the wall (i.e., an 8" wall should rest on a footer 16" wide).
 - 3) Where temperatures drop below 32 degrees F., footers should be placed below the frost line to prevent damage.
 - a) The frost line is the maximum depth that the soil freezes.
- b. A trench is dug by backhoe or shovel with the width and depth corresponding to the footing size.
- c. Concrete is poured into the trench and leveled to the desired height of the footing.
- d. Use a regular 5:1 concrete mix for the footing.
- e. Make sure to install a horizontal reinforcement bar to strengthen the footing from the weight created by the block wall.
- f. Vertical reinforcement should be used if the wall is to be higher than three feet. It should be placed so it will pass through one core of every two to three blocks; this, however, depends on wall length.

E. Mortar Preparation

1. Ingredients

- a. Masonry cement (mortar mix)

130M-33

- 1) When purchased, the correct proportions of lime have already been added to portland cement.
- 2) Sacks come in 1 cubic foot amount with the correct amount of sand to be added printed on the sack.

b. Mortar Sand

- 1) This is special-sized sand for the specific purpose of use in mortar mix.
- 2) Regular sand can be used but it must be screened to remove the larger particles.
- 3) For general work, about three parts of sand are added to one part of mortar mix.

c. Water - Add just enough water to make the mix workable i.e., pliable enough to support the units on a 3/8" mortar joint until it has set.

- 1) If mortar is too stiff (not enough water) it will not bond tightly to the block.
- 2) If it is too thin, it will be squeezed out of the joint by the weight of the block. If this happens, the joint will be less than 3/8."

2. Mixing

a. Small Batches

- 1) Mix the mortar in a mortar pan, wheelbarrow, or a leak proof pan.
- 2) Stir or mix with a mortar hoe or regular garden hoe.
- 3) Mix dry materials to a uniform color before adding water.
- 4) After adding water, mix mortar thoroughly until it is pliable and workable.

b. Large Batches (more than two wheelbarrows full)

- 1) Use a motor or engine-driven mixer to ensure more thorough and efficient mixing.
- 2) Some of the water should be added first, then the dry materials, and, finally, the amount of water needed to obtain the right consistency.

F. Laying Block

1. Methods

- a. Use a corner pole to ensure that the block are laid straight and plumb at each end of the wall.
 - 1) A corner pole is a straight piece of wood or metal held plumb by diagonal supports.
 - a) It is used to support the builder's line to which the wall is built.
 - b) The pole also has lines marked on it which represent the correct height of each course.
- b. A carpenter's level can also be used as a guide to lay block corners.
 - 1) The level can be used to both level and plumb the block.
 - 2) The corners are built first and then the areas between them are filled with courses of stretcher block. A line is used to keep the courses straight.

NOTE: The following procedure uses the corner pole method where the builder's line is repositioned after each course is laid. The height of each course is constantly checked to be a full 8 inches by using the marks on the corner poles.)

2. Procedures

- a. Start from a corner with a corner-shaped block.
- b. Spread a full layer of mortar (mortar bed) on the footing.
 - 1) The webs of the block as well as the face shells or outer edges are bedded in mortar.
 - 2) Place about 1/2" of mortar on the footing so when the block is pushed into it firmly the bed measures 3/8 of an inch.
- c. Lay the first corner block carefully.
 - 1) Position it so the outside corner is exactly where the outside corner of the wall should be.
 - 2) Place it so the thinner part of the web is down.
 - 3) Level the block, first crosswise and then lengthwise.

130M-35

- 4) Use the trowel handle to tap the block into position and level it.

d. Lay the second (stretcher) block.

- 1) Stand a block on end and butter (apply mortar to) the two projecting ends (ears) with a downward wiping or swiping stroke with the trowel.
- 2) Put the block firmly in place and level it.

e. Lay several stretcher block by working away from the end or corner.

1) Check the first course for:

- a) Levelness crosswise and lengthwise
- b) Outside edges for plumb
- c) That the block forms an even straight line.

2) Use the end of the trowel handle until each block is plumb, level, and the course is straight.

f. In preparation for the second course, apply a mortar bed to the top of the first course.

- 1) Above the first course, it is necessary to apply mortar only to the face shells or outer edges.
- 2) Some local codes require full bedding for all courses so check local codes before starting a job.

g. If extra strength is needed, install reinforcement wire in the mortar bed.

h. Trim off excess mortar with the edge of the trowel as the block laying progresses.

i. To reposition the builder's line after each course is laid the line is positioned to be level along the top of the block.

j. Check the height to be sure each course is an additional 8 inches high.

k. If a block must be cut to a certain size:

- 1) Use a mason's hammer and make multiple strikes along the line to be cut.
- 2) Then make one sharp rap on the edge of the web.

130M-36

- 3) Try to keep cutting of blocks to a minimum since it hurts the appearance of the project and drastically increases the labor required to finish a job.

l. As work progresses and the mortar begins to dry and stiffen, the joints can be tooled.

- 1) Joints should be compacted and finished.

- a) This produces a tight, water-resistant joint.
- b) It also emphasizes the joint lines and gives the job a neat appearance.

- 2) Tools are available to create a variety of joints such as concave, V-shaped, or raked.

- a) A flush joint can be obtained by rubbing it with a broken piece of block. If the wall is to be plastered or stuccoed, leave the joint flush.

m. Pouring the grout for reinforcement

- 1) All block cores holding vertical steel reinforcement rods must be filled solid with grout.

- a) Grout mix contains 5 parts sand to 1 part cement; it is mixed very wet.
- b) If desired, gravel can also be used.

- 2) A tamping rod should be used to ensure that the grout goes down to the footing.

- 3) A solid, reinforced concrete pier will be formed in the wall.

n. For a wall supporting a roof frame where wooden plates need to be fastened:

- 1) Embed 1/2-inch anchor bolts 18 inches long in grout in the cores of the top two courses.
- 2) Space the bolts no more than 4 feet apart.
- 3) Metal lath (wire mesh) is placed two courses down to support the bolts.

o. The final step in building with block is the finishing of the top.

- 1) The top of the wall may be finished with any of the following methods:
 - a) A solid masonry course using solid-top block or solid 2-inch-thick cap block. This course must be laid with as much care as the first course.
 - b) A course of decorative, design blocks.
 - c) A crown of regular mortar mix round and trowel smooth supported by metal lath in the course below.
 - d) A flush top of block with cores filled with mortar mix supported by metal lath in the course below.

ACTIVITY:

1. Have students complete the project planned in the beginning of this lesson. (If you are not an expert mason do not worry, contact a local concrete or mason contractor for some advice. Don't be surprised if they are willing to come out and donate their time.)
2. Take students to a job site where masonry construction is being done.

SAFETY IN MASONRY WORK

Observe the following general safety practices in doing all masonry work.

1. Wear proper safety equipment. When doing masonry work, wear safety glasses, safety shoes, and a hard hat.
2. Wear gloves. Masonry units and concrete are abrasive. Wear gloves to protect your hands when you handle these products.
3. Wear a respirator. When working in masonry dust, wear a filter-type respirator.
4. Check equipment before you use it. Be sure that hoists, scaffolds, and ladders are properly assembled and secured before you use them.
5. Stack masonry materials carefully. Masonry materials such as concrete blocks and dry cement are bulky and heavy; if improperly stacked, they can easily fall, causing injury.
6. Operate concrete and mortar mixers cautiously. Be certain all guards are in place and if a mixer is electric, that it is properly grounded.
7. Use chemicals with extreme care. Many chemicals needed for masonry work, such as muriatic acid and trisodium phosphate, are harmful to the skin and clothing and must be used carefully. When using masonry chemicals, wear rubber gloves to avoid damaging your skin.
8. Check all concrete forms. Poorly constructed forms endanger lives. Check them for strength and safety before you use them.

9. Place tools in a convenient location. Place tools for working convenience but never where you or others would be endangered.
10. Know proper lifting procedures to avoid back injuries.

* Reprinted by permission of Interstate Publishers, Inc., from MODERN AGRICULTURAL MECHANICS, 2nd ed., by Stanley R. Burke and T. J. Wakeman. Copyright 1992 by Interstate Publishers, Inc.

Name _____

Date _____

Score _____

CONCRETE AND MASONRY, UNIT EXAM

Circle the best answer.

1. Concrete is a mixture of sand, gravel, water, and _____?
 - a. clay cement
 - b. finishing cement
 - c. finishing lime
 - d. portland cement

2. The strength and durability of concrete are dependent on the:
 - a. purity of water
 - b. ratio of stone aggregates by size
 - c. type of cement
 - d. all of the above

3. To prevent forms from sticking to the concrete, they are treated with:
 - a. fat
 - b. paint
 - c. form oil
 - d. wax

4. Concrete is reinforced with:
 - a. air bubbles
 - b. steel bars
 - c. wood fibers
 - d. aluminum wire

5. Concrete is cured by:
 - a. covering with plastic, straw, etc.
 - b. protecting from wind
 - c. sprinkling with water
 - d. all of these

6. A standard sack of portland cement contains:
- 94 pounds
 - 90 pounds
 - 1.5 cubic yards
 - 1 cubic yard
7. The process of "striking off" the excess concrete to match the top edge with the form is called:
- troweling
 - brooming
 - floating
 - screeding
8. After screeding concrete, what tool is used for floating?
- Straight Edge
 - Broom
 - Bull Float
 - Finishing Trowel
9. The groover or jointer is used to cut joints in concrete slabs while the edger is used to round off corners.
- True
 - False
10. When using a mixer, load all the coarse aggregate and all the specified water with the mixer stopped. Then follow the remaining steps as indicated.
- True
 - False
11. Concrete is finished with a steel trowel:
- after the water sheen has disappeared
 - after the surface has dried
 - immediately after the second floating of the surface
 - immediately after the concrete is poured
12. The presence of organic matter and silt in the water or aggregates used in concrete does not reduce the strength or durability of the concrete.
- True
 - False

13. When working with concrete, which step comes first?
- a. Screeding
 - b. Tamping
 - c. Floating
 - d. Troweling
14. An acceptable range of slump for general purpose concrete used in an agricultural situation is:
- a. 2" to 8"
 - b. 6" to 10"
 - c. 1" to 3"
 - d. 3" to 6"
15. To obtain a non-skid finish that will assure the best traction, use a:
- a. bull float
 - b. broom
 - c. wood float
 - d. steel trowel
16. If the sand to be used in concrete is considered "wet":
- a. more water should be used in the mix.
 - b. less water should be used in the mix.
 - c. more gravel should be used in the mix.
 - d. none of the above.
17. The strength of concrete is determined by the ratio of:
- a. water to sand
 - b. cement to gravel
 - c. sand to gravel
 - d. water to cement
18. The maximum size coarse aggregate to be used in a wall is:
- a. 1/4 the wall thickness
 - b. 1/5 the wall thickness
 - c. 1/3 the wall thickness
 - d. 1/2 the wall thickness

19. In a 1 : 2 1/4 : 2 3/4 mix ratio, the one (1) refers to the proportion of _____.
- a. water
 - b. coarse aggregate
 - c. fine aggregate
 - d. cement
20. In the cement ratio 1:2:3, the amount of fine aggregate would be:
- a. three times the amount of cement
 - b. two cubic feet
 - c. two times the amount of cement
 - d. three cubic feet
21. Which of the following tools is most appropriate for squaring forms for a large concrete slab?
- a. Carpenter's square
 - b. Try square
 - c. Surveyor's level
 - d. Tape measure to lay out a right triangle
22. One cubic yard of concrete is equal to:
- a. 3 cubic feet
 - b. 9 cubic feet
 - c. 27 cubic feet
 - d. 144 cubic feet
23. The actual size of a standard concrete masonry block is:
- a. 7 3/8 X 7 3/8 X 15 3/8
 - b. 7 5/8 X 7 5/8 X 15 5/8
 - c. 8 X 8 X 16
 - d. 8 3/8 X 8 3/8 X 16 3/8
24. A six gallon paste mix should contain 6 gallons of water per sack (cubic foot) of:
- a. concrete
 - b. cement
 - c. sackrete
 - d. mortar mix

25. _____ is a mixture of sand, portland cement, water, and finishing lime.

- a. Sackrete
- b. Concrete
- c. Mortar
- d. Grout

26. Drinking water generally is suitable for mixing concrete.

- a. True
- b. False

27. Concrete allowed to cure for one month will be about twice as strong as concrete which is allowed to dry immediately.

- a. True
- b. False

28. How many standard size blocks will it take to lay a 16 foot wall that is 2 feet high?

- a. 30
- b. 36
- c. 40
- d. 42

29. How many cubic yards of concrete must be ordered to pour a 4 inch slab for a 24 foot by 27 foot shop floor?

- a. 8
- b. 27
- c. 216
- d. 2592

(NOTE: To complete the rest of the test handouts covered in the previous lessons must be given to the students.)

A concrete driveway is to be poured on a level surface. The concrete is to be ordered from a "batch" (Ready Mix) plant. The dimensions of the slab are: 6 inches thick, 16 feet wide, 54 feet long. Allow 5% overage for uneven surface of the ground.

SHOW ALL YOUR WORK!

30. How many cubic feet of concrete are needed to complete the job?

_____ cubic feet

31. How many cubic yards should be ordered?
(Round off answer to nearest 1/4 or 1/2 of cubic yard.)

_____ cubic yards

32. Specify the maximum size of aggregate.

_____ inches

33. Specify the proportions desired for a one sack batch.

_____ : _____ : _____
CEMENT SAND GRAVEL

34. Specify the amount of cement needed for 1 cubic yard of concrete.

_____ sacks

35. Specify the water - cement ratio used for the job at hand.

_____ gallon paste

36. Specify the amount of slump.

_____ inches

37. Calculate the Ready Mix cost. (\$55.00/Cubic Yard)

\$ _____

38. Now that you are experienced masons, you can go out and pour some concrete on your own! Right?

- a. True
- b. False

130M-45

Unit Exam

Worksheet #1

Worksheet #2

1. D
2. D
3. C
4. B
5. D
6. A
7. D
8. C
9. A
10. B
11. C
12. B
13. B
14. D
15. B
16. B
17. D
18. B
19. D
20. C
21. D
22. C
23. B
24. B
25. C
26. A
27. A
28. B
29. C
30. $454 (453.6) = 16' * 54' * 6''$
31. $17\text{cu.yd.} (16.8\text{cu.yd.}) = 454/27$
32. 2"
33. 1:2:3
34. $4.5 = 27/6$
35. $6 \frac{1}{2}$
36. 3"-4"
37. $\$935 = 17\text{cu.yd.} * \55
38. ?

1. 1.7" ($1 \frac{1}{2}'' - 1 \frac{3}{4}''$)
2. 1:2:3
3. 4.5 or $4 \frac{1}{2}$
4. 9 sand $13 \frac{1}{2}$ gravel
5. 45sks 90 cu/ft sand
135cu/ft gravel

1. 10 sacks
2. $\frac{1}{2}$ yd (.40 rounded up)
3. A. 3 sacks ($2 \frac{1}{2}$ sacks rounded up)
B. 5.1cu/ft
 $\frac{1}{2}$ cu/yd = 13.5 cu/ft
 $1 + 2 + 2.25 = 5.25$
 $13.5 / 5.25 = 2.57$
 $2.57 * 2 = 5.14$ or 5.1
- C. 5.8cu/ft
 $2.57 * 2.25 = 5.78$ or 5.8

References:

Burke, Stanley R., & Wakeman, T. J. (1990). MODERN AGRICULTURAL MECHANICS (2nd ed.). Danville, IL: Interstate Publishers.

Cooper, Elmer L. (1987). AGRICULTURAL MECHANICS:FUNDAMENTALS AND APPLICATIONS. Albany, NY: Delmar Publishers.

Editors of Reader's Digest. (1973). COMPLETE DO-IT-YOURSELF MANUAL (7th ed.). Pleasantville, NY: Reader's Digest Association.

Wagner, Willis H. (1979). MODERN CARPENTRY: Building Construction Details in Easy-to-Understand Form (4th ed.). So. Holland, IL: Goodheart-Willcox.

U.S. Dept. of the Army. CONCRETE, MASONRY, AND BRICKWORK: A PRACTICAL HANDBOOK FOR THE HOMEOWNER AND SMALL BUILDER. New York: Dover Publications.

Resources:

Ahrens, Donald L. (1988). CONCRETE AND CONCRETE MASONRY. Available from: Hobar Publications, 1234 Tiller Lane, St. Paul, MN 55112
Phone: (612) 633-3170 (Catalog available)

Midwest Plan Service. (1980). STRUCTURES AND ENVIRONMENT HANDBOOK. (10th ed.). Available from: Midwest Plan Service, 122 Davidson Hall, Iowa State University, Ames, Iowa 50011

Special Materials and Equipment:

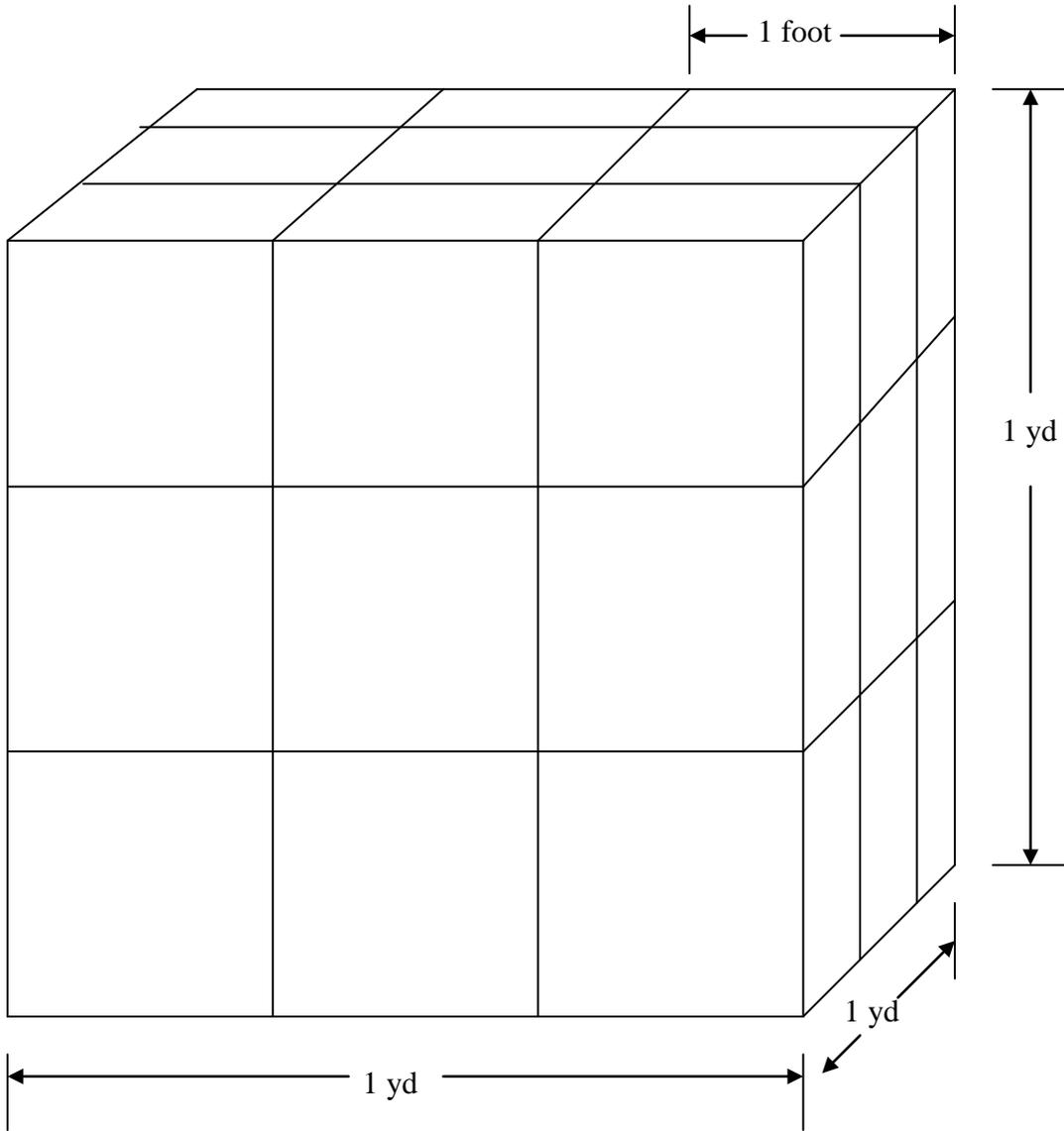
Calculators, volume container examples

Form and batter boards, builder's twine, stakes, wire mesh, rebars, wire, level, nails, hammers, rakes, 100 ft. tape, shovels, Brick trowel, edger, groover, wood or magnesium float, screed board, finishing trowel, wheelbarrow, bull float, tamper, push broom, slump cone w/rod, water hose, shovels, also possibly concrete ingredients, portable mixer, power trowel, Brick trowel, wheelbarrow, water hose, shovels, level, builder's line, jointer, mortar board, mortar ingredients, portable mixer: also possibly rebars, anchor bolts, sill lumber, and assorted examples of masonry

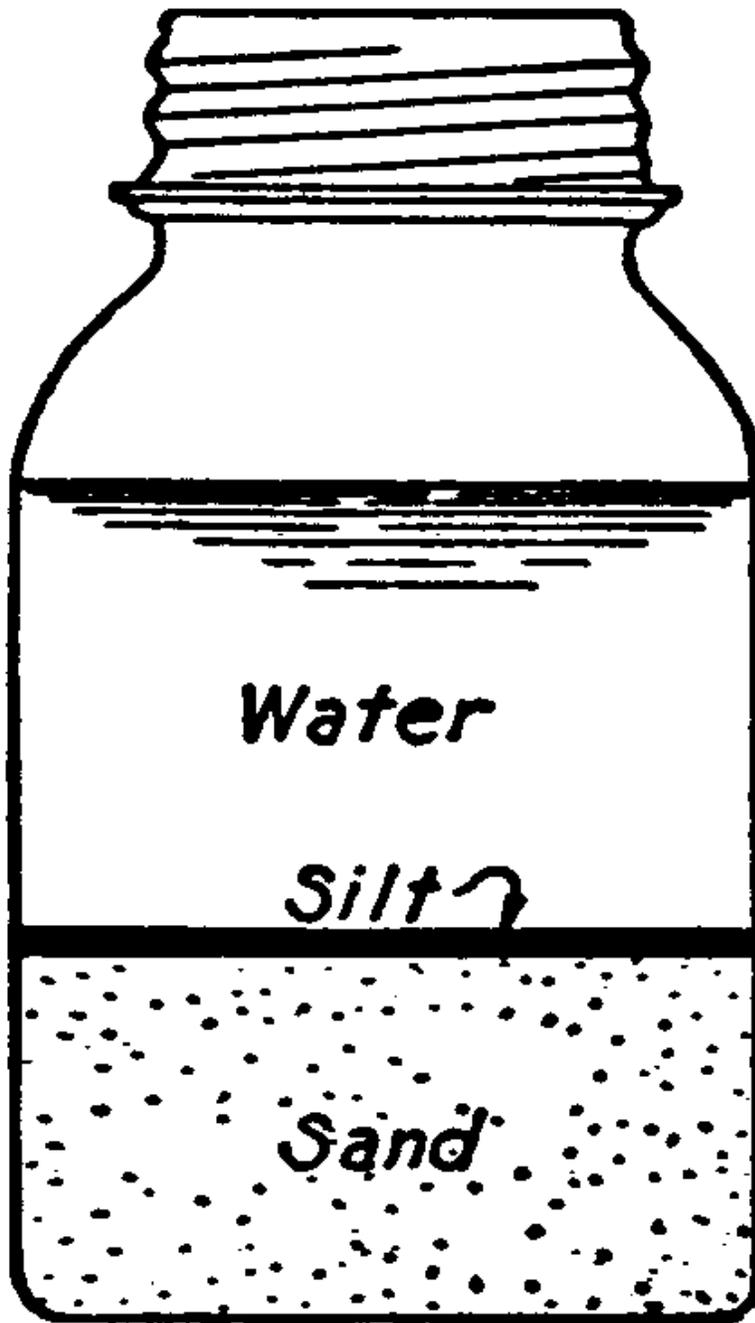
MIXTURE RATIOS

Kind of work	Mixture Ratios			Required water per sack of cement when sand is---		
	Cement, Sacks	Sand, ft ³	Gravel, ft ³	Wet Gal.	Moist Gal	Dry Gal
Very thin work, 2 to 4 inches thick (milk cooling tanks)	1	2	2	3 ½	3 ¾	4 ½
Abrasion resistance, 4 to 8 inches thick (stock tanks, driveways)	1	2	3	3 ¾	4 ½	5 ½
General reinforced, 8 to 12 inches thick (basement walls, steps)	1	2 ½	3 ½	4 ½	5	6 ½
Mass concrete, (footings, foundation walls)	1	3	5	5	6	7

130M-48

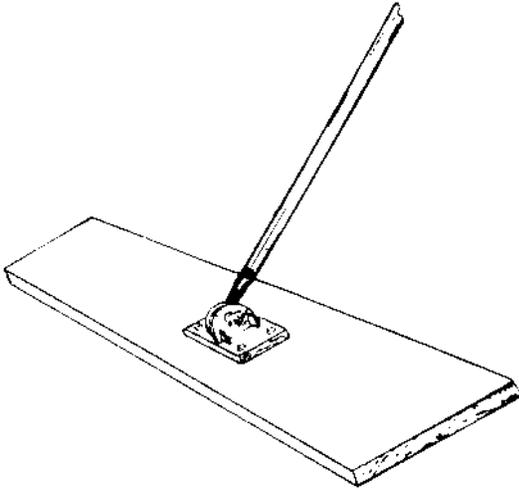


1 cubic yard = 27 cubic feet

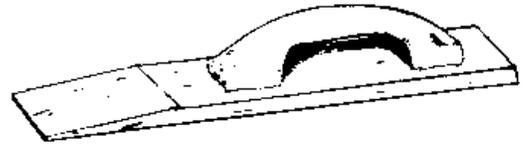


Silt Test

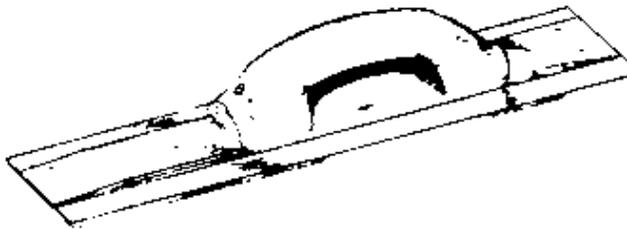
TOOLS USED IN CONCRETE WORK



BULLFLOAT



WOOD FLOAT

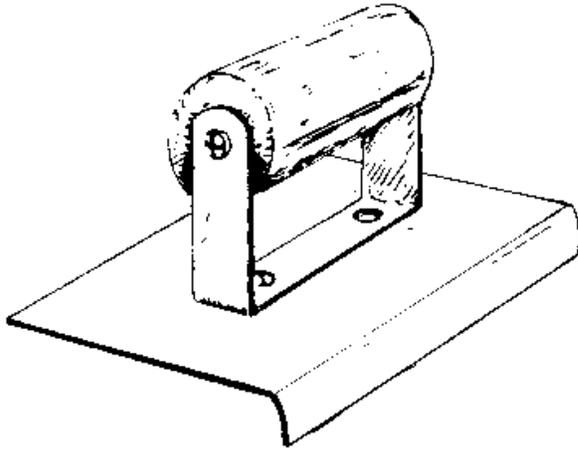


MAGNESIUM FLOAT

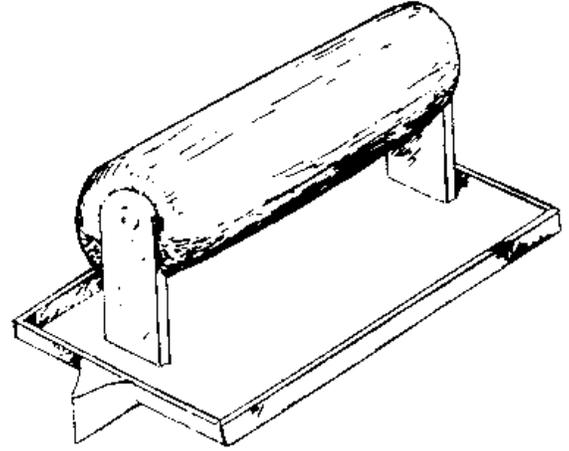


FINISHING TROWEL

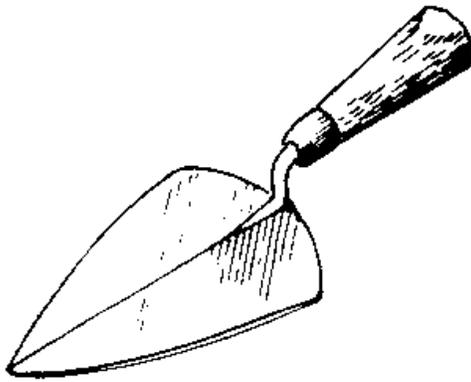
TOOLS USED IN CONCRETE WORK



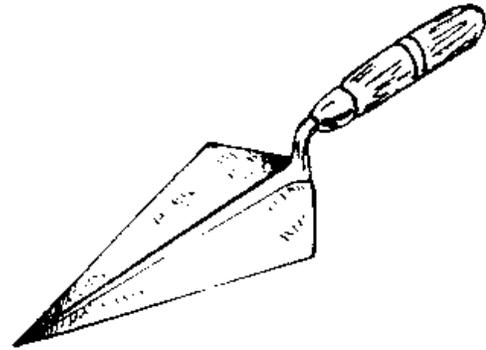
EDGER



JOINTER OR GROOVER



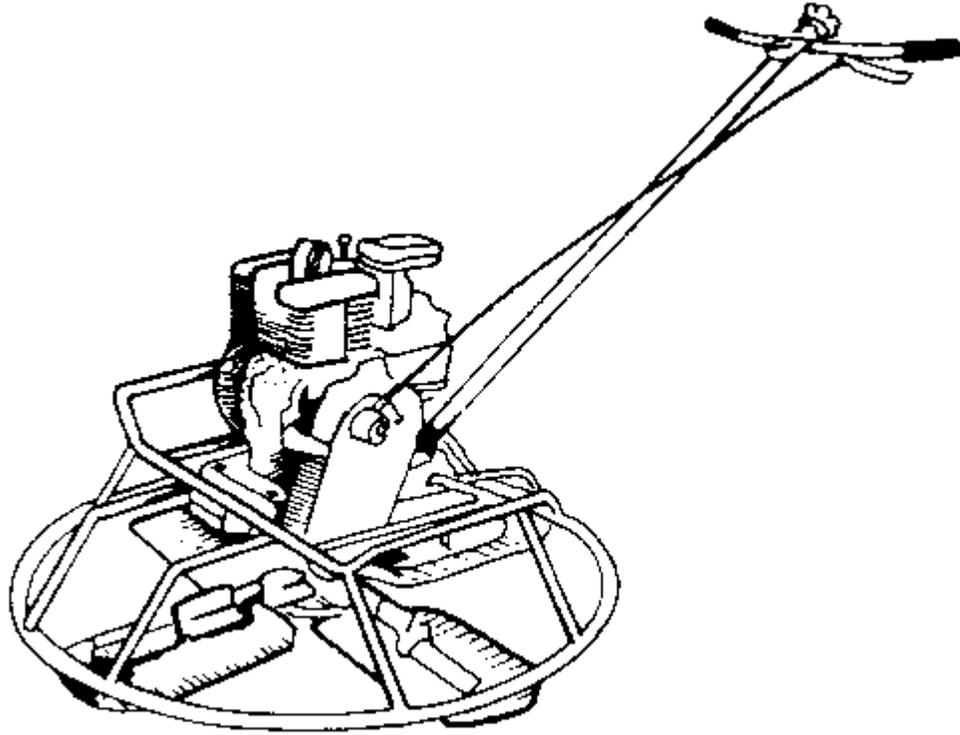
BRICK TROWEL



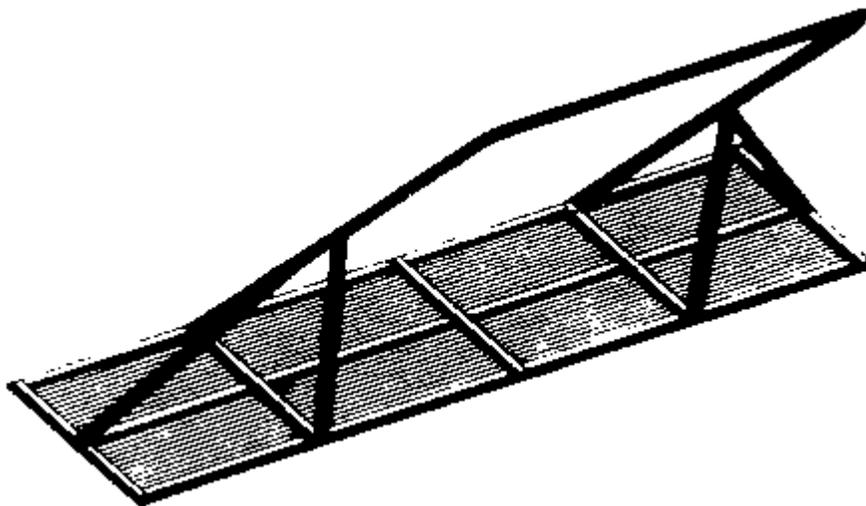
POINTING TROWEL

130M-52

TOOLS USED IN CONCRETE WORK



POWER TROWEL



HAND TAMP

130N-1

FASTENERS

AG 130-N

UNIT OBJECTIVE

After completion of this unit, students will be able to identify fasteners used power, metal fabrication, and structures and understand the advantages and disadvantages of each. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Identify five samples of each of the various fasteners used in power, metal fabrication, and structures.
2. Demonstrate the ability to select the proper fasteners and hardware for specific jobs or for situations encountered in agricultural mechanics projects.

TYPES AND USES OF FASTENERS

A. Importance of Fasteners

1. They simplify the manufacture of machines and structures.
 - a. Fasteners reduce the need for large one-piece parts; it is normally much simpler to make less complex components and fasten them together.
2. They simplify repair of structures and equipment.
 - a. Individual component parts can simply and quickly be separated for inspection, repair, or replacement.
3. They provide safety.
 - a. Use of fasteners tends to assure that once an assembly is fastened together it will hold together. They can be installed to provide additional support or they can be the weak link that prevents dangerous major equipment failures (for example, shear pins on driveshafts and breakaway plowshares).

B. General Types of Fasteners

1. Bolts, Nuts, and Washers
2. Screws
3. Keys
4. Studs
5. Pins
6. Rings
7. Rivets
8. Adhesives
9. Nails

C. Specific Types and Uses of Fasteners

1. Bolts are threaded lengths of steel rod with heads on one end; they are used with a nut at the other end and sometimes with a washer as well.
 - a. American Standard (Hexagonal or Square-head) Bolts
 - 1) Most bolts have a hexagonal (6-sided) head although some older bolts have a square (4-sided) head.

130N-3

- 2) Bolts are used with flat washers to fasten wood parts together and with or without lock washers to hold steel parts together.
- 3) Without a nut they are called cap screws and are used by screwing into a threaded hole.
- 4) Bolts are often selected by strength rating and/or chemical or temperature compatibility.

b. Carriage Bolts

- 1) Most have a round head with a square neck under the head although some have a flat, countersunk head; still others have finned or ribbed necks.
- 2) Carriage bolts are used to fasten wood parts or steel parts with square punched holes where a smooth finish is desired.

c. Plow Bolts (countersunk, square-neck carriage bolt)

- 1) These have flat, tapered heads that fit into countersunk holes in plowshares or other similar parts.
- 2) Plow bolts are used when it is necessary for the head to lie flush with the surface of the part, for example, attaching cultivator shovels to a standard and all components of a moldboard plowshare.

2. Nuts are flat, usually hexagonally-shaped steel pieces with internally cut threads that are screwed onto the threads of bolts.

a. Square nuts are also common; knurled round nuts are less common.

b. Jam Nuts

- 1) These are normally thinner than hex and square nuts and used to lock a standard nut into place by running up against the hex or square nut.
- 2) They are commonly used where vibration or cyclic loads may cause a bolt to unscrew.

c. Castellated and Slotted Nuts

- 1) These are hexagonal nuts with slots in the sides which resemble in appearance the walls of a castle that has been slotted for archers.

130N-4

- 2) These are used when a cotter pin is placed through a hole in the bolt to secure the nut so it cannot come loose, for example, on wheel bearing spindles.

d. Self-locking Nuts

- 1) Once tightened, these nuts stay firmly in place.
- 2) They are commonly known as "elastic," prevailing-torque, or plastic-insert nuts.
- 3) They take the place of nuts with jam nuts and are generally more compact.

3. Washers

- a. Plain washers (flat washers) are steel disks with a hole in the center.

- 1) They are used to reduce the stress under a bolt or nut.
- 2) They spread the clamping force from the bolt over a larger area as would be needed with wood. They also span slots and oversize holes.

b. Lock Washers

- 1) Helical spring washers are made of tough, spring steel and normally installed under the nut (but they can also be used under the bolt, particularly cap screws).
 - a) The dimensions are specified like a plain washer.
 - b) They are used to prevent rotation of the nut.
- 2) Toothed ("shakeproof") lock washers give special holding power because the many sharp, heat-treated teeth to dig into the surfaces pressing against them.
 - a) They may have external, internal, or external/internal teeth.
 - b) They offer greater contact area to protect parts and provide a flat mating surface.

4. Screws are threaded lengths of steel rod with heads on one end.

130N-5

- a. Screw heads may be slotted for common screwdrivers, cross slotted for Phillips screwdrivers, square or hexagonally shaped for wrenches or other shapes described below.
 - b. Sheet metal screws are also known as thread-forming or tapping screws.
 - 1) They are used to attach light, thin parts made of sheet metal, soft metal castings, plywood, fiberglass, plastics, etc.
 - 2) The screw forms its own threads in the parts that it is screwed into.
 - c. Set screws are used to hold a collar, pulley, gear, etc. on a rotating shaft and in fractional horsepower applications; they prevent relative rotation between the two.
 - 1) They commonly have a hex (Allen) socket head but may also have a square or slotted head.
 - 2) A variety of point (tip) styles are available, ranging from cupped to flat to cone-shaped.
 - 3) Set screws are not an especially strong type of fastener and will normally score or raise a burr on the shaft which may make the part held to the shaft difficult to remove. Use of a flat or cavity on the shaft will prevent this.
 - d. Hex socket cap screws have a hole in the head of the screw made to fit a hex (Allen) wrench.
 - 1) They are used in recessed holes or in confined spaces where the small head size may be an advantage.
 - e. 12-point flange-head screws have external teeth around the heads to allow use of a small 12-point box-end wrench.
 - 1) These are used where small-diameter, high-strength screws are required, for example, on hydraulic motors.
5. Keys are square, rectangular, or semicircular-shaped steel pieces that are commonly used to hold a gear, pulley, or other part from rotating on a shaft.
- a. Both the shaft and the part to be held have a groove (keyway) cut into them.

130N-6

- b. A Woodruff (semi-circular) key extends deeper into the shaft and tends to eliminate "rocking" that may occur with square or rectangular keys.

6. Studs are steel rods with threads on both ends.

- a. One end is screwed into a part, while other parts are assembled over the stud and secured in place with a nut.

- 1) For example, studs are commonly used to attach the head of the engine to the engine block.

- b. Many studs have coarse ("interference") threads on one end and fine threads on the other.

- 1) The coarse threads go into the pilot hole and compress when screwed in to create the locking action.

7. Pins

- a. Spring pins (rollpins) are hollow cylinders of spring steel which are split lengthwise and chamfered at both ends.

- 1) They are made slightly oversize so they compress when driven or pressed into place.

- 2) They are frequently used to secure items to shafts for both thrust and rotary loads.

- b. Dowel pins are solid round steel pins used to assure that the fastened parts align exactly as they are designed.

- 1) The diameter of the dowel pin is slightly larger (0.0002" over) than that of the hole it is to be driven into.

- c. Quick-lock pins are square-shaped pins with a spring-like circular wire piece at one end which serves as an overcenter clip.

- 1) They are commonly found on 3-point hitches of tractors and implements.

8. Snap rings provide removable shoulders to accurately locate, retain, or lock components together against thrust loads.

130N-7

- a. Internal snap rings fit inside grooves in holes.
 - b. External snap rings fit inside grooves on shafts.
9. Rivets are soft metal pins with heads on one end.
- a. The common solid rivet is used primarily to hold two or more flat parallel parts together, for example, sheet metal parts and sickle sections on mower cutter bars.
 - b. The blind (pop) rivet can be installed in a joint which is accessible from one side only, for example, sheet metal boxes or enclosures and for sheet metal patches.
 - 1) Blind rivets are intended for light duty only.
10. Adhesives are glue-like materials which are spread on the two surfaces to be joined.
- a. Adhesives are used to join dissimilar materials or complex parts which would otherwise be difficult to join with conventional fasteners or welding techniques.
 - b. Most adhesives are affected by the environment in which they are used and their strength may be adversely affected by temperature and exposure to moisture or other liquids.
 - c. There are limitations to what materials may be effectively bonded with a specific adhesive, i.e., the "universal" adhesive does not exist.
 - d. Epoxy
 - 1) It is composed of two parts, a resin and a hardener, that must be mixed together.
 - 2) It is excellent for general repairs but can be expensive.
 - 3) Epoxy is commonly used on non-porous materials like metals and ceramics; it can also be used on woods and fabrics but they can as easily and cheaply be held together with white glue.
 - e. PVA (polyvinyl resin adhesive) Adhesives
 - 1) A common example of PVA adhesives is white glue (such as Elmer's) that comes in a bottle ready to use.
 - 2) White glue is suited to most interior woodworking and household repair jobs where high strength and dampness are not factors.

130N-8

f. Resorcinal and Formaldehyde

- 1) Both adhesives are excellent for bonding wood to wood where structural strength is required.
- 2) Both require mixing, resorcinal with a resin and formaldehyde with water.
- 3) Formaldehyde is recommended for indoor use only due to its poor weather resistance qualities.
- 4) Resorcinal can be used in exterior applications due its superior resistance to water.

g. Silicone is used primarily as a sealing material in gaskets found in high temperature applications (up to 400 degrees F.). Room temperature vulcanizing (RTV) silicone is used for calking and making positive seals when used with conventional gaskets.

- 1) It is water and oil resistant.

h. Mastic

- 1) Synthetic latex mastic is water-based.
- 2) Rubber resin mastic is essentially synthetic rubbers in a solvent.
- 3) Both materials bond well to concrete, hardboard, asphalt, leathers, textiles, and ceramic tile.
- 4) Mastic is used for roof patching, asphalt sealing, and securing plywood panels to dry walls.

11. Nails

a. Nails are steel rods with a head on one end and usually pointed at the other end. They are used primarily to join wood together.

b. Common Nail

- 1) This is a general purpose construction nail suitable for framing of structures. It has a larger diameter than the same size box nail.

c. Box Nail

- 1) Box nails are used for end nailing and light household use.
- 2) The point is dulled to prevent splitting of wood.

130N-9

- 3) It has a smaller diameter than a common nail to help avoid splitting.

d. Finishing Nail

- 1) This is a nail with a small head with a dimple in the center to allow for countersinking with a nail set.
- 2) Countersunk finishing nails are used in cabinetry or paneling.

e. Duplex (double headed) Nail

- 1) A duplex nail has two heads on the shank.
- 2) It is used whenever the nail is to be removed, for example, in assembling concrete forms.

f. Wire Staple

- 1) This is a "U" shaped nail.
- 2) It is used in fence construction and electrical wiring.

h. Roofing Nail

- 1) This nail is used to secure shingles or roofing to the underlying structure; it has an oversized head.
- 2) They are normally available with either a spiral or helix-threaded shank for extra holding power.

i. Flooring Nail

- 1) It is used to fasten hardwood floorboards.
- 2) It has a plain shank between the head and threads and can be installed with a floor nailing machine.

Activity:

1. Test different methods of fastening 2 X 4s together with different fasteners, follow instructions on page 130N-17.
2. Using a press or any means available, break apart the test boards and record the results.

SELECTION OF FASTENERS

A. Specifications for Fasteners

1. Bolts

- a. Type (i.e., common, carriage, plow, etc.)
- b. Size

- 1) Diameter of the crest of the threads

- c. Length

- 1) Measured from the bottom of the bolt head to the end of the threads

- d. Threads

- 1) Specified by the number of threads per inch and by manufacturing tolerance of threads

- 2) Threads per Inch:

- a) UNC designated threads (coarse) are the most common in agricultural components.

- b) UNF (or SAE) designated threads (fine) are used in special conditions, for example, where parts being joined have thin walls.

- 3) Manufacturing tolerance (re fit) of threads.

- a) Thread class symbol such as 1A, 2A, etc.

- e. Grade (or property class) of bolts as delineated below:

Grade Marking*	Specification**	Material	Tensile Strength (psi)
No lines	SAE Grade 0	Low carbon steel	
No lines	SAE Grade 1	Low carbon steel	60,000
No lines	SAE Grade 2	Low carbon steel	74,000
3 lines	SAE Grade 5	Medium carbon steel, quenched and tempered	120,000
5 lines	SAE Grade 7	Medium carbon steel, quenched and tempered	133,000
6 lines	SAE Grade 8	Medium carbon alloy steel, quenched and tempered	150,000

- * Radial slashes on bolt head which are present on all bolts 1/4" or greater in diameter.
- ** Grades 2 and 5 are most common in agricultural equipment. Grade 8 is common to engines, power transmission, and other high loading conditions.

f. Descriptive Symbols for Specifying Bolts

1) Example:

1/2 - 20 UNC - 2A X 3

where,

1/2 = Bolt size (diameter) in inches

20 = Number of threads per inch

UN = Stands for Unified Screw Thread Standard

C = Coarse thread

2A = Thread class (fit) symbol

3 = Length of bolt (inches)

2. Nuts

- a. Type (hexagonal, square, castellated, jam, wing, cap)
- b. Size

1) Diameter of the bolt to be used with the nut

- c. Threads

1) Same as for bolts, i.e., UNC or UNF

3. Washers

- a. Type (plain, lock, etc.)
- b. Actual inside diameter in inches
- c. Bolt size that will fit through the inner hole in inches

1) Actual hole is approximately 1/32" larger than the bolt diameter.

- d. Thickness of the washer in terms of the gauge of the metal that it is made from

4. Screws (less than 1/4" in diameter)

130N-12

- a. Type (sheet metal, set, etc.)
- b. Size as specified below:

Screw Number	Diameter (in.)	Approximate Fraction
No. 2	0.086"	>5/64"
No. 3	0.099"	>3/32"
No. 4	0.112"	>7/64"
No. 5	0.125"	1/8"
No. 6	0.138"	>9/64"
No. 8	0.164"	>5/32"
No. 10	0.190"	>3/16"
No. 12	0.216"	<7/32"

c. Length

- 1) Distance from the bottom of the screw head to the tip of the thread

d. Number of Threads per Inch

e. Head shape

- 1) Pan head
- 2) Flat head
- 3) Cross-recessed head (Phillips head)
- 4) Hex head
- 5) Allen socket head
- 6) Round head
- 7) Truss head
- 8) Oval head
- 9) Fillister head

5. Keys

- a. Type (square, Woodruff, etc.)

6. Studs

- a. Size in terms of the diameter
- b. Type of thread at each (stud and nut) end
- c. Thread length at each end of the stud
- d. Combined thread and "grip" length of the nut end

7. Pins

- a. Type (spring, dowel, etc.)
- b. Diameter of the pin
- c. Length of the pin

8. Rings

- a. Type (internal or external)
- b. Internal snap ring
 - 1) Inside bore (hole) diameter
 - 2) Groove diameter
 - 3) Ring width
- c. External snap ring
 - 1) Outside shaft diameter
 - 2) Groove diameter
 - 3) Ring width
- d. Spiral rings (internal and external)
- e. "C" and "D" rings (external)

9. Rivets

- a. Type (common, blind, etc.)
- b. Diameter
- c. Length

10. Adhesives

- a. Type (epoxy, PVA, silicone, mastic, etc.)
- b. Materials to be Joined
 - 1) Read the instructions for use of the adhesive to be sure that it is effective on the materials to be joined
 - 2) Request material safety data sheets.
- c. Environment
 - 1) Read the instructions for use of the adhesive to be sure that it is effective in the environment in which the joined materials will be placed

d. Holding Power

1) Strength provided by the bond

e. Setting time

f. Curing time

11. Nails

a. Type (common, box, finishing, etc.)

b. Nail size or length of the nail as designated by the term "penny" and written as, for example, a "10d nail" which designates a 3-inch nail. (The penny abbreviation "d" derives from the denarius, an early Roman coin.)

1) The length of common nails (through a 10 penny nail) can be determined by dividing the penny by 4 and adding 1/2."

2) For example, the length of a 6 penny nail is:

$$a) 6/4 + 1/2 = 1-1/2" + 1/2" = 2 \text{ inches.}$$

<u>Size</u>	<u>Length in Inches</u>
2d	1
3d	1 ¼
4d	1 ½
5d	1 ¾
6d	2
7d	2 ¼
8d	2 ½
9d	2 ¾
10d	3
12d	3 ¼
16d	3 ½
20d	4
30d	4 ½
40d	5
50d	5 ½
60d	6

c. Nail Shank Treatment

1) Bright nails are untreated.

2) "Cement" coated nails are actually coated with a resin.

130N-15

- 3) Chemically etched nails are designed to provide a rougher shank surface.
- 4) Annularly threaded nails have circular threads around the shank to give a better grip than a bright nail.
- 5) Helically (spirally) threaded nails have screwlike threads about the shank.

a) They hold better than bright nails and are commonly used to attach stair treads.

- 6) Helically barbed nails are deformed for greater withdrawal resistance.
- 7) Zinc coated nails are coated to provide stain and corrosion resistance but will also give greater gripping strength than bright nails.

d. Nail Point

- 1) A variety of nail points are manufactured in order to allow for faster penetration or to reduce wood splitting.
- 2) Some of the nail points available include:

a) Needle, pilot, chisel, wedge, blunt, long, etc.

e. Nail Head

- 1) Head selection is primarily based upon the materials being attached, i.e., the softer the material the larger the head.
- 2) Finishing nails have a small head with a dimple to allow for countersinking.
- 3) When building forms or temporary structures, double headed nails will allow for quicker disassembly.

References:

Cooper, Elmer L. (1997). *AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS*, 3ed EDITION. Albany, NY: Delmar Publishers.

Editors of Reader's Digest. (1973). *COMPLETE DO-IT-YOURSELF MANUAL* (7th ed.). Pleasantville, NY: Reader's Digest Association.

Resources:

Baumeister, T., & Avallone, E. A. (1987). *Marks' STANDARD HANDBOOK FOR MECHANICAL ENGINEERS* (9th ed.). New York: McGraw-Hill.

Deere & Company. (1987). *FASTENERS* (3rd ed.) (Fundamentals of Service (FOS) Series). Available from: John Deere Technical Services, Dept. F, John Deere Road, Moline, IL 61265 (Available in Spanish)

Oberg, Erik, Jones, F. D., & Horton, H. L. (1990). *MACHINERY'S HANDBOOK* (23rd ed.). New York: Industrial Press.

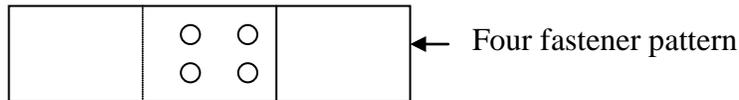
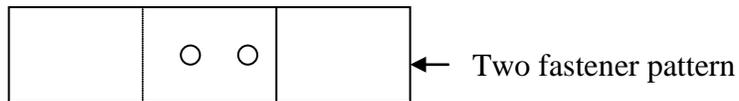
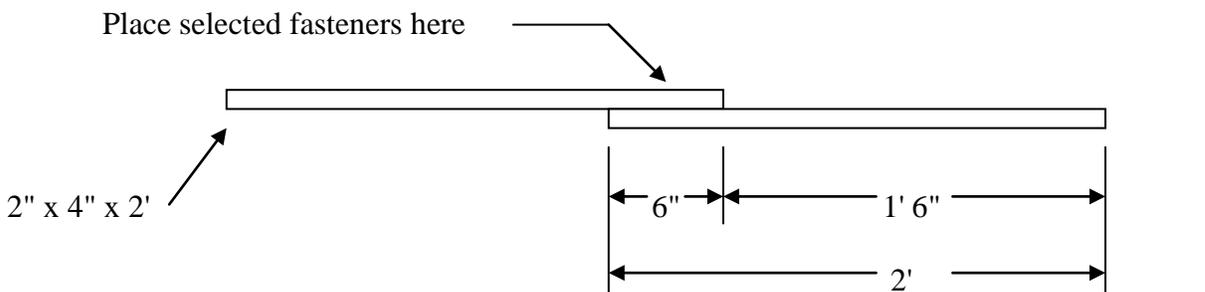
Special Materials and Equipment:

Assortment of fasteners and associated hardware, Assortment of fasteners and materials to fasten together, 2x4s, wood screws, lag screws, carriage bolts, nails, etc.

Activity Sheet #1
Testing Fasteners

Break students up into groups of two or three. Have each group make a different fastener test board using the directions and chart below. Some groups might do more than one test board

Fasten two 2 x 4s together with a 6 inch overlap using nails, wood screws, lag screw, or carriage bolts. On some boards glue will be required, be sure to check the chart number before fastening boards together.



- Board #1 2 nails
- Board #2 2 wood screws
- Board #3 2 lag screws
- Board #4 2 carriage bolts
- Board #5 2 nails with glue
- Board #6 2 wood screws with glue
- Board #7 2 lag screws with glue
- Board #8 2 carriage bolts with glue
- Board #9 4 nails
- Board #10 4 wood screws
- Board #11 4 lag screws
- Board #12 4 carriage bolts
- Board #13 4 nails with glue
- Board #14 4 screws with glue
- Board #15 4 lag screws with glue
- Board #16 4 carriage bolts with glue

Nails, use size 10d and clench
 Wood Screws, use 2 1/4" wood screws
 Lag Screws, use 1/4" x 2 1/4" lag screws
 Carriage Bolts, use 1/4" x 3" carriage bolts
 Glue, use Elmer's wood glue

Note – pre-drill holes for screws and bolts

Name(s) _____

Board # _____

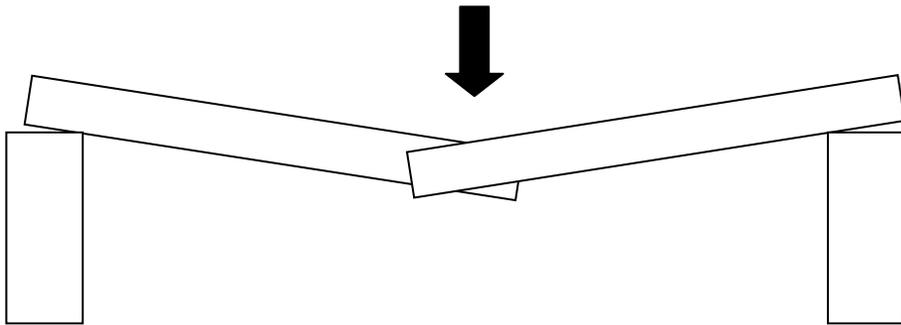
After each board has been tested and write down the results in the proper space and the findings at the bottom of the page.

What gave first? The wood or the fastener?

How many pounds of pressure did it take to break the connection?

How did the glue help the joints? Etc.

Shear Strength Test



Results:

Board #1 _____

Board #2 _____

Board #3 _____

Board #4 _____

Board #5 _____

Board #6 _____

Board #7 _____

Board #8 _____

Board #9 _____

Board #10 _____

Board #11 _____

Board #12 _____

Board #13 _____

Board #14 _____

Board #15 _____

Board #16 _____

Record the Findings:

Name _____

Date _____

Score _____

FASTENERS, UNIT EXAM

Match the fastener on the right to the correct description on the left by placing the appropriate numbers in the blank.

- | | |
|--|------------------|
| _____ 1. Round head with a square neck. | A. Set Screw |
| _____ 2. Flat, tapered head with a square neck. | B. Rivet |
| _____ 3. Used where vibration may cause bolt to unscrew. | C. Duplex |
| _____ 4. Used with a cotter pin | D. Wire Staple |
| _____ 5. Steel disk with a hole in the center | E. Plain Washer |
| _____ 6. Used to hold on a pulley. | F. Carriage Bolt |
| _____ 7. Soft metal pins with heads on one end. | G. Castle Nut |
| _____ 8. Used to hold wire in fence construction | H. Plow Bolts |
| _____ 9. A nail with two heads. | I. Jam Nuts |
| _____ 10. A nail with a small head. | J. Finish Nail |

Answer the following questions with a short answer.

11. How long is a 9d nail? _____
12. What are "Cement" coated nails covered with? _____
13. What type of nail are used in cabinetry or paneling? _____
14. What type of adhesive is composed of a resin and a hardener? _____
15. They are commonly know as "elastic," preventing torque, or plastic-insert nuts.

16. Are horse shoe nails fasteners? Yes/no and why.

130N-20

Answer Sheet

1. F
2. H
3. I
4. G
5. E
6. A
7. B
8. D
9. C
10. J
11. $2 \frac{3}{4}$ " $9/4 + 1/2 = 2 \frac{3}{4}$
12. Resin
13. Finish Nails
14. Epoxy
15. Self Locking Nut
16. Yes, They hold the shoe on.

130N-21

TYPES OF NAILS



8d Hinge



Plaster Board



Roofing



Shingle

Lead Head



Flooring



Box



Duplex



Wire Staple



Finishing



Common

130N-22

TYPES OF SCREWS

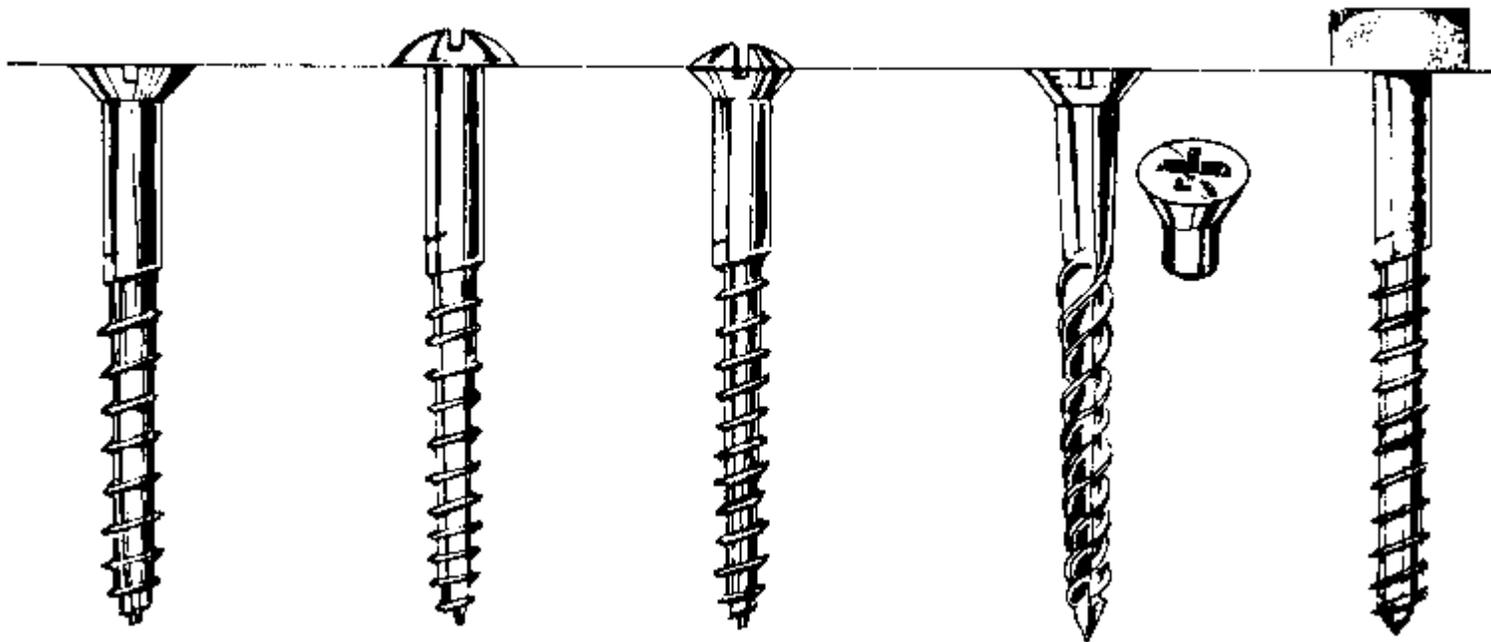
Flat Head

Round Head

Oval Head

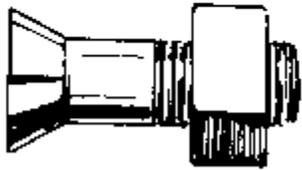
Phillips

Lag



130N-23

TYPES OF BOLTS



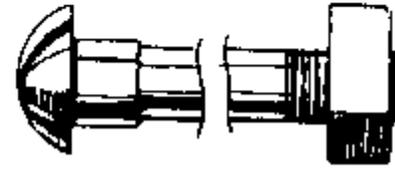
Plow



Round Head



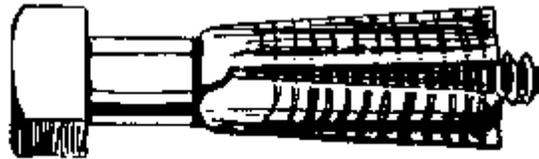
Flat Head



Carriage



Machine



Expansion



Toggle



Eye Bolt



Hook Bolt



U Bolt



Turnbuckle

130N-24

TYPES OF WASHERS



Plain Flat Washer



Star Lock Washer
External



Star Lock Washer
Internal - External



Common Lock Washer



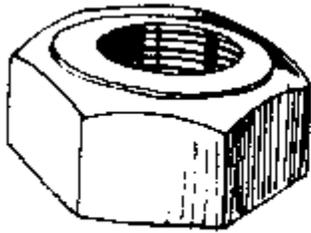
Star Lock Washer
Internal



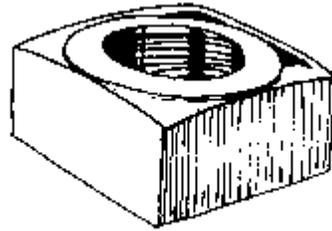
Star Lock Washer
Countersunk

130N-25

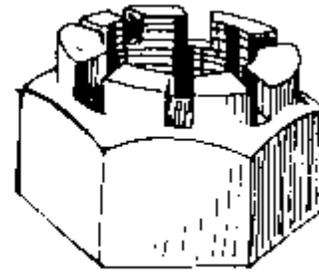
TYPES OF NUTS



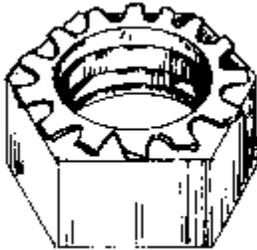
Hexagon



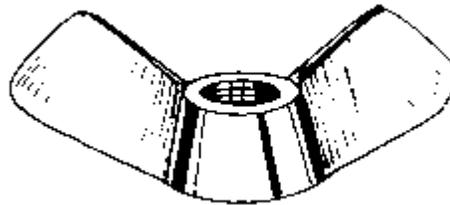
Square



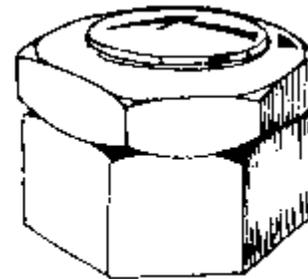
Castle or Slotted



Self-locking



Wing Nut



Jam or Lock Nut

130O-1

PAINTING, BRUSH & SPRAY

AG 130-O

UNIT OBJECTIVE

After completion of this unit, students will be able to identify the different way to apply paint using a brush or spray gun to different surfaces.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Understand proper cleaning procedures for painting tools
2. Name five tools necessary for spray painting.
3. Name the functions on each adjustment found on a spray gun
4. Understand the purpose of surface preparation
5. Understand how to select the right paint for the job

A. Terms and Definitions

1. Alkyd – is a synthetic resin used in paint instead of oil
2. Exterior paint – paint made to be used outside where water may be present
3. Interior Paint – used indoors, protected from rain and other elements
4. Lacquer – a colored (or clear) liquid material used to protect and enhance the appearance of metal
5. Latex-based Paint – water-based paint, tools can easily be cleaned with water
6. Paint – material that colors and protects surfaces
7. Pigment – color of the paint material
8. Polymerization –
9. Primer – a special paint used to prepare the surface for painting
10. Sealer – a material the provides a coating over the surface of wood to keep moisture out
11. Spray Painting – applies the paint in a mist of paint blown on to the surface being painted
12. Varnish – a transparent liquid material used to protect and enhance the appearance of wood
13. Wood Preservative – prevents the decay of wood by rot and insects

SPRAY PAINTING

A. Tools Necessary for Spray Painting

1. Spray Gun
 - a. Pressure Gun
 - b. Suction Gun
2. Air Compressor
3. Paint Pressure Tank
4. Hose
 - a. Air
 - b. Paint
5. Air Control Device
 - a. Pressure Gauge
 - b. Regulator

B. Adjustment for Spray Guns

1. Spreader – controls air to holes which regulates size of spray pattern
2. Fluid Adjustment – controls the travel of the fluid needle which allows more or less material through the fluid tip
3. Procedures for adjusting spray gun
 - a. Open spreader adjustment valve
 - b. Open fluid needle screw
 - c. Check air leaks
 - d. Connect hose to cup
 - e. Remove nozzle
 - f. Press trigger until paint passes through gun
 - g. Replace nozzle and set pressure

C. Prepare paint for spray painting, procedure

1. Shake paint can to mix the material or use a mixing stick, paint stores have a mechanical shaker
2. Pour paint through a strainer into the spray gun cup
3. Add thinner until the paint becomes thin enough to drip off the mixing stick like milk.

D. Using the Paint Gun

1. Hold the spray gun 6 to 10 inches away from the surface to be painted. If the spray gun is held any further away the paint tends to dry before reaching the surface.
2. Start with the gun pointing off to the side and move into the area to be painted, move the gun along the area to be painted and stop painting after you moved off the end.
3. Overlap half of the previous pass.

E. Cleaning the Paint Gun

1. Pour remaining paint back into the paint can
2. Add one ounce of thinner to the cup to rinse the paint, pour the remainder into the paint can
3. Use a paper towel to wipe out the remaining paint in the cup
4. Add thinner to the cup and spray thinner through the spray gun until the thinner comes out clear
5. Use the remaining thinner in the cup to wipe any excess paint off the spray gun

PAINING WITH A BRUSH

A. Brushes

1. Brushes are classified by:

- a. Width – 3 to 4 inches in painting wall and 1 to 2 inches for painting trim
- b. Bristle and Foam – most bristles are made of nylon and clean easily after use, foam brushes are intended to be thrown away after being used
- c. Handle – select brushes with long comfortable handles easy to grip
- d. Kind of Paint – most brushes can be used for most types of paint, select a brush for the kind of paint being used

B. Caring for the Brush

1. Cleaning

- a. Brushes used to apply water-based paints can be cleaned by holding them under running water.
- b. Work the bristles by hand until the clean water comes out of the bristles.
- c. Brushes can be washed in a container with a mild dish washing detergent.
- d. Brushes used to apply oil-based paint should be cleaned in paint thinner
- d. Hang by the handle to dry

2. Storage

- a. Store brushes in their original container to protect its' shape
- b. Brushes can be stored wrapped in paper
- c. Bristles bend out of shape make it more difficult to paint

C. Using a Brush

1. Hold the brush lightly, keeping the arm and wrist muscles relaxed to avoid fatigue.
2. Dip the brush into paint about one-third the length of the bristles
3. After dipping, rub the brush gently against the inside surface of the paint can to remove excess paint
4. Paint section of a wall in 2-foot square foot sections, paint wood with the grain

D. Paint volume

1. One gallon of paint can generally cover 400 square feet, using section 130C as a guide you can figure how many square feet are in a room, minus the doors and windows

A. Surface Preparations

1. Wood

- a. The surface must be clean and any holes must be filled and sanded before painting
- b. Moldy areas on wood must be cleaned with bleach. 1-2 cups per gallon of water
- c. Remove any old paint that is peeling or loose
- d. The surface should be thoroughly dry before painting

2. Metal

- a. Metal should be free of rust and corrosion before painting can begin
- b. Machinery can be steam cleaned to remove grease, dirt, and oil
- c. Use only paints that are made for metal

B. Selection of Paint

1. Wood

- a. Interior Paint
- b. Exterior Paint

2. Metal

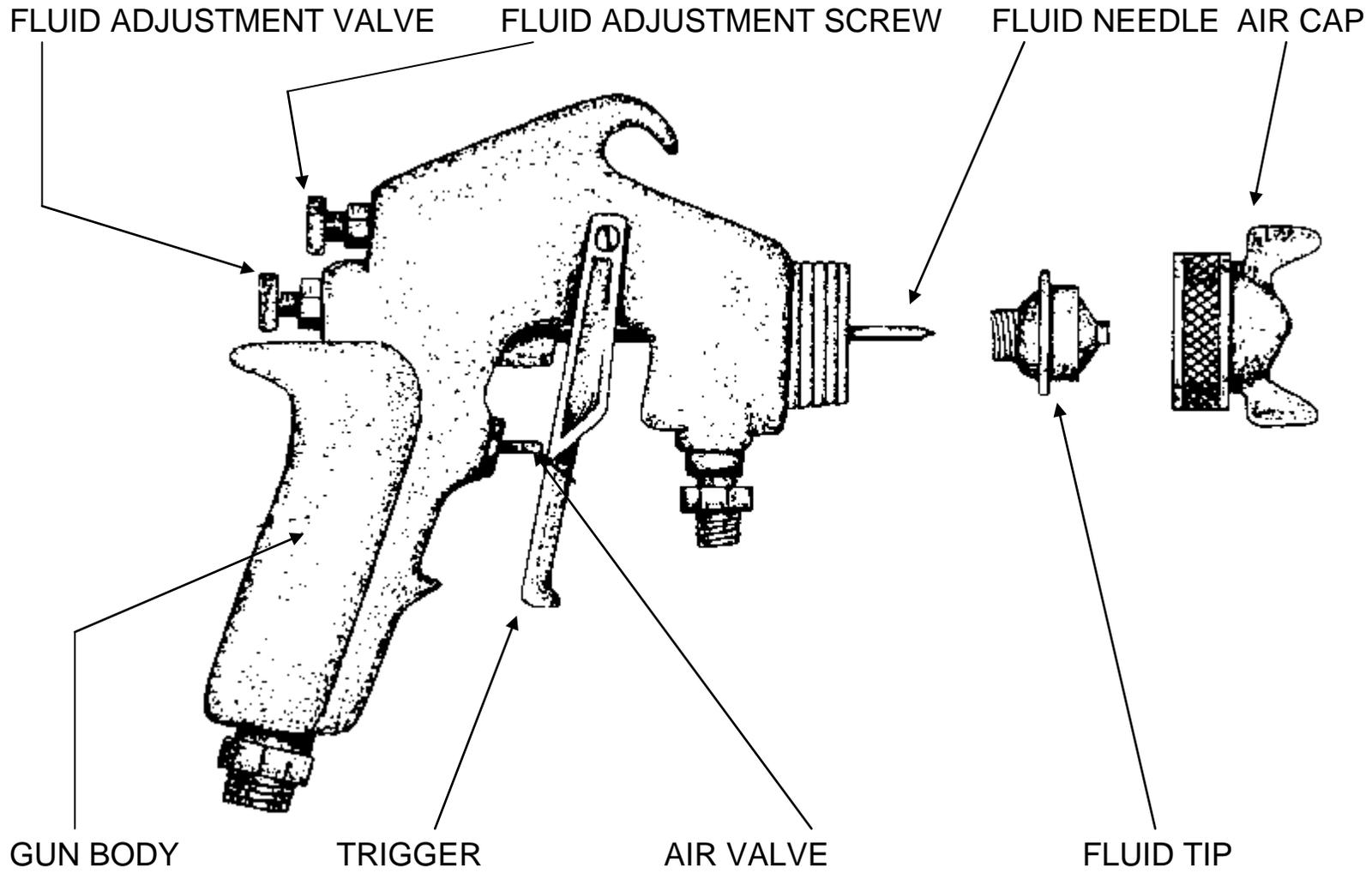
3. Read the label on the paint container for list of applications

References:

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3rd EDITION. Albany, NY: Delmar Publishers.

Phipps, Lloyd J., and Miller, Glen M. (1998) AGRISCIENCE MECHANICS. Danville, IL: Interstate Publishing

1300-6
PARTS OF A SPRAY GUN



130P-1

BUILDING STRUCTURES, FRAMING & RAFTERS

AG 130-P

UNIT OBJECTIVE

After completion of this unit, students will be able to identify the importance and scope of the agricultural mechanics industry in the United States, Idaho, and the local community. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. List factors to consider when planning a farm building.
2. Label types of doors used on farm utility buildings.
3. List common types of foundations and wall supports.
4. List factors to consider when selecting roofing materials.
5. List factors to consider when selecting siding material.
6. List ways to protect siding from decay or damage.
7. Distinguish among paints and the types of surfaces on which they are used.
8. List characteristics to look for when selecting paint.
9. Determine the cost of a farm building.

BUILDING STRUCTURES

A. Terms Used in Building Structures, Framing & Rafter Construction

1. Sill – Horizontal timbers which form the lowest members of a frame supporting the superstructure of a building.
2. Stud – An upright member, usually a piece of dimension lumber, used in the framework of a wall.
3. Plate – Term usually applied to a 2 X 4 placed on top of studs in frame walls.
4. Purlin – A beam spanning the principle roof supports
5. Ridge – The highest point of a roof composed of sloping sides.
6. Truss – A combination of members such as beams, bars, and ties usually arranged in triangular units such to form a rigid framework for supporting loads over a ling span.
7. Rafters – Sloping members of a roof such as the ribs which extend from the ridge or from the hip of a roof to the eaves.
8. Girder – A large supporting built-up horizontal member used to support walls or joists.
9. Gusset – A brace or angle bracket used to stiffen a corner or angular piece of work.
10. Knee Brace – A framing member placed across the inside of an angle in a frame work to add stiffness to the frame.
11. Utility building – Building designed to be used for a variety of purposes. (equipment storage, animal shelter, shop, service center, etc)
12. Span – Distance from outside of top wall plate on one exterior wall to outside of top wall plate on opposite wall.
13. Run – Horizontal distance from center of ridge board to outside of wall plate.
14. Pitch – Slant or slope of a roof, the proportion of the rise to the span
15. Rise – Vertical distance from top of wall plate to top of ridge board.
16. Ridge Board – Horizontal member at top of the roof to which the upper end of the rafters are attached.
17. Seat Cut – the cut at the end of the rafter that rests on the plate
18. Slope – the slant of a rafter, it is the rise per foot of the run
19. Upper Plumb Cut – the vertical cut at the top end of the rafter
20. Lower Plumb Cut – the vertical cut at the lower end of the rater

B. Factors to Consider, When Planning a Farm Building

1. Decide the size of building needed.
2. Decide the location of the building.
3. Decide the type of building needed.
4. Decide the kind of materials to use.

5. Consult persons experienced in building and in the use of agricultural buildings.
6. Figure bill of materials and the total cost of the building (look under AG 130-I)
7. Decide to build it yourself or hire a contractor to build it. (consider; time, labor costs, size of the project, the tools it will take to construct a building, etc and if using a contractor, several bids should be considered)
8. Alternate Uses
9. Future Expansion

C. Factors to Consider, When Selecting Roofing Materials

1. Probable life expectance due to weathering
2. Fire resistance
3. Annual snow fall
4. Resistance to heat and sun
5. Resistance too strong wind
6. Maintenance
7. Minimum slope for application
8. Weight
9. Kinds of fasteners required
10. Labor and Cost
11. Skill required for construction
12. Type of roofing material
 - a. Galvanized steel
 - b. Aluminum sheets
 - c. Wood shingles
 - d. Asphalt shingles
 - e. Asphalt roll
 - f. Fiberglass sheets
 - h. Steel sheets with backed on enamel

D. Factor to Consider, When selecting siding material

1. Life expectancy due to weathering
2. Fire resistance
3. Resistance to attack by vermin
4. Maintenance
5. Ability to be painted
6. Type of fastener needed
7. Cost
8. Ease of construction
9. Protecting Siding from Decay or Damage

130P-4

- a. Use treated lumber
- b. Keep siding at least 6" above ground level
- c. Provide drainage away from all sides of the building
- d. Provide eave troughs and down spouting to keep water from spilling on sides.
- e. Provide 8" to 20" of overhang on all sides of the building
- f. Paint and characteristics to look for when selecting paint
 - 1) Durability
 - 2) Self-cleaning (wears off gradually and keeps the surface relatively clean)
 - 3) Highly reflective
 - 4) Dirt resistant
 - 5) Non-sensitive to moisture (resistant to blistering and peeling)
 - 6) Good hiding or covering qualities

E. Types of Doors

1. Sliding

- a. Attaches to a track.
- b. Can be made to fit.
- c. Can be made of almost any type of material.

2. Overhead

- a. Commonly used on garages.
 - b. Mounted on track or guide.
 - c. Raised out of the way when open.
 - d. Attractive
 - e. More convenient to operate
 - f. Higher cost
- Limited in number of sizes

3. Walk-Through

- a. Most common for all buildings
- b. Small size
- c. Used primarily for human traffic
- d. Easy to install
- e. Ease in entering a building

E. Common types of foundations and wall supports

1. Wood or steel poles or posts and piers
2. Light wood frame with masonry or concrete foundation
3. Post and girt with masonry or concrete foundation
4. Masonry walls on concrete foundations
5. Steel structures
6. Combinations of above

F. Types of Floors, Advantages and Disadvantages

1. Dirt

a. Advantages

- 1) Least expensive
- 2) Absorbs oil and water

b. Disadvantages

- 1) Tools and equipment sink into the dirt.
- 2) If floor is damp it provides enough moisture to rust tools and equipment.
- 3) If the floor is dry, dust will usually be a problem with each gust of wind.
- 4) Very difficult to clean

2. Crushed Rock

a. Advantages

- 1) Dust is much less of a problem
- 2) Absorbs oil and water

b. Disadvantages

- 1) Not satisfactory in livestock structure of cleaning problems
- 2) It holds dirt and grease
- 3) Tools and equipment will

3. Concrete

a. Advantages

130P-6

- 1) If properly placed, forms a hard dry surface
- 2) Easy to keep clean
- 3) Forms an excellent base for equipment and power tools
- 4) Excellent for livestock structures
- 5) It is fireproof and usually costs less than a wooden floor

b. Disadvantages

- 1) Colder than wooden flooring
- 2) More tiring to stand on when working continuously
- 3) More expensive than most types of flooring

4. Wood

a. Advantages

- 1) Warmer during cold weather
- 2) Less tiring to stand on for long periods of time

b. Disadvantages

- 1) More expensive than most floors
- 2) May not be strong enough to support heavy equipment
- 3) Fire hazard especially in a shop
- 4) Short life compared to concrete

E. Type of Farm Utility Buildings

1. Shed - Roof
2. Gable – Roof
3. Half – Arch
4. Full – Arch
5. Pole Barn

F. Factors to consider when selecting siding

1. Life expectancy due to weathering
2. Fire resistance
3. Maintenance
4. Ability to be painted
5. Type of fasteners needed
6. Ease of construction

G. Factors to consider when selecting paint

1. Durability
2. Highly reflective
3. Dirt resistant
4. Resistant to rain and discoloration
5. Use

I. Causes of building failures

1. Builder did not use the grade and type of material called for in the specifications
2. Builder did not make joints as strong as the structural member
3. Inadequate foundation

FRAMING

A. Components in Framing

1. Sills – a 2" X 4" (or 2" X 6" depending on the studs used) attached to the foundation
2. Studs – The upright wall members, usually spaced 16" (note the marks on a tape measure at 16, 32, 48, 64 etc. are used in spacing studs) or 24" to provide modular spacing that conforms with common building materials. The width of the stud depends on the building loads, ceiling height and building codes for type of buildings.
3. Plates – the horizontal member on top of the studs, it adds strength to the wall and must be wide enough to support the rafters
4. Headers – are required to span openings such as windows and doors, often used with the regular plates that are already in place.

B. Connections in Framing

1. Toe-nailing (See Page 130P-17)
 - a) Toe-nailing is nailed through the face of the boards and not the edges, if nailed through the edges the chances of splitting increase.
 - b) Position the point of the nail so that one-third of the nail is in the stud and two-thirds in the sill or plate.
2. End-nailing (See Page 130P-17)
 - a) Nailing through the sill or plate into the stud

3. Clinching

- a) When the nails go through the two pieces of wood being nailed together the excess needs to be bent over into the wood.

4. Nailing into the grain

- a) Nail across the grain of the wood to prevent the wood from splitting.
- b) Nailing with the grain will result in splitting and weaken the board.

C. Bracing in Framing

1. Lateral bracing

- a) Lateral bracing in a frame is obtained by a brace (usually a 1" X 4") notched into the studs, at each corner in both directions.
- b) Using plywood to cover the frame gives the best support for bracing.

2. Knee bracing

- a) Knee bracing is used between columns and beams for lateral resistance to wind.
- b) Knee braces should be made of 2" X 4" and a minimum of 4' in length (mostly used in pole barn or out building construction).

D. Framing Doors and Windows

1. Header – a 4" X 8" piece of lumber used for framing the tops of doors and windows to support the upper walls or roof
2. Double header – two 2" X 8" pieces of lumber fastened together used as a header
3. Filler studs – studs used for supporting headers, always attached to a full stud
4. Cripple studs – studs placed at the normal spacing (16 or 24 inches) above and below windows and above doors
5. Sill header – a horizontal piece of lumber used at the bottom of a window frame; sometimes, double sills are used for larger windows

RAFTER FRAMING

A. Terms Used in Rafter Framing

1. Rise – the vertical distance from the top of the plate to the center of the work line
2. Run – the horizontal distance from the outer edge of the plate to the center of the ridge, on equal pitch roofs the run is equal to one-half the span
3. Span – the distance between structural supports
4. Ridge – the horizontal line at the junction of the top edges of two sloping roof surfaces, the rafters of both slopes are nailed to a board at the ridge
5. Slope – the incline of a roof, expressed as inches of rise per foot of run
6. Pitch – the ratio of the total rise to the total width of a building; example, 8' rise and a 24' width make a 1/3 pitch
7. Tail – the part of the rafter that overhangs the eave of the building
8. Common Rafter – a structural member of a roof in a straight line from the plate to the ridge
9. Valley Rafter – a rafter which runs from a wall plate to the ridge, along the valley of a roof
10. Jack Rafter – a rafter placed between the top plate and a hip rafter or a valley rafter to a ridge board
11. Hip rafter – a rafter that extends from the wall plate to the ridge of the roof and forms the angle of a hip roof

B. Use of A Framing Square

1. Parts of a framing square
 - a. Body – the longer and wider member, 24" in length and 2" wide
 - b. Tongue – the shorter and narrower member, 16" in length and 1 ½" wide
 - c. Heel – the outside edge where the body and tongue meet
 - d. Face – Holding the tongue in the right hand with the body pointing toward the left hand and the heel pointing away from you, you will be looking at the face. The manufacture's name is usually on the face side of a framing square.
 - e. Back – Holding the tongue in the left hand with the body pointing toward the right hand and the heel pointing away from you, you will be looking at the back.

2. Tables on the Framing Square

(Note; books on how to read these tables and scales can be found at your local hardware store)

- a. Rafter table – this table is found on the face-side of the body and can be used as a short cut to figuring out rafter length
- b. Octagon scale – this scale is found on the face-side of the tongue and can be used in construction of eight sided structures
- c. Brace measure – this table is found on the backside of the tongue and gives the length of common braces
- d. Essex board measure – the table is found on the backside of the body and can be used for measuring board feet

C. Cutting a Common Rafter (See Page 130P-15)

1. Determine the slope

- a. Slope = inches of rise for each foot of run

2. Determine the length

3. Mark off the length of the rafter as calculated from the rafter table

4. Mark out the plumb cut

5. Mark out the seat cut

6. Make an allowance for the thickness of the ridge piece

7. Add the amount of stock needed for the rafter tail

8. Cut the rafter and check the fit of the seat and plumb cuts

References:

Wagner, W. H. (1987). MODERN CARPENTRY. South Holland, IL: Goodheart Willcox.

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Phipps, Lloyd J., and Miller, Glen M.(1998) AGRISCIENCE MECHANICS. Danville, IL: Interstate Publishing

Burke, Stanley R., and Wakeman, T. J. (1990) MODERN AGRICULTURAL MECHANICS, 2ed EDITION. Danville, IL: Interstate Publishing

Lindley, J. A., & Whitaker, J. H. (1996) AGRICULTURAL BUILDINGS AND STRUCTURES, REVISED EDITION. American Society of Agricultural Engineers, St. Joseph, MI, <http://asae.org/>

Name _____

Date _____

Score _____

Worksheet, Rafter Cutting

Using a 1" X 4" 4' piece of lumber you will cut out a rafter to the following specification. Answer questions 1 and 2 before marking out the rafter, double check with your instructor before making any cuts.

1. What is the slope of your rafter? You have 12" of rise to 36" of run.

Slope = _____

2. What is the length of your rafter? $A^2 + B^2 = C^2$ or use the rafter table on a framing square. (Show your work)

Rafter Length = _____

3. Mark off the length of the rafter as calculated.

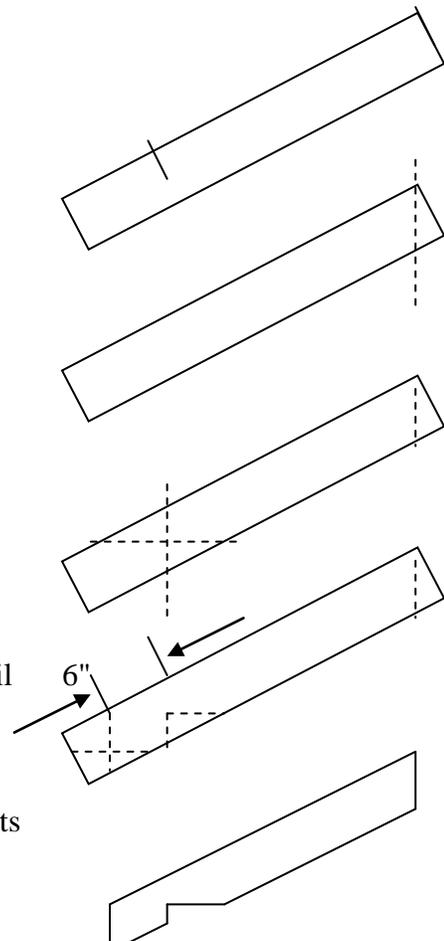
4. Mark out the plumb cut using a framing square.

5. Mark out the seat cut to fit a 1 3/4" X 3 3/4" plate.

6. Mark and add 6" to the rafter length for the rafter tail

7. Cut rafter and check the fit of the seat and plumb cuts

8. After you have completed your rafter cuts, turn in your rafter with this worksheet for grading



Name _____

Date _____

Score _____

Unit Exam, Structures, Framing & Rafter Cutting

Match terms on the left with the correct definitions on the right.

- | | |
|---|---------------------|
| 1. _____ Building designed to be used for a variety of purposes. | A. Sill |
| 2. _____ Sloping members of a roof which extend from the ridge of a roof to the eaves. | B. Rise |
| 3. _____ The cut at the end of the rafter that rests on the plate | C. Slope |
| 4. _____ Horizontal distance from center of ridge board to outside of wall plate. | D. Span |
| 5. _____ An upright member, usually a piece of dimension lumber, used in the framework of a wall. | E. Ridge |
| 6. _____ Term usually applied to a 2 X 4 placed on top of studs in frame walls. | F. Run |
| 7. _____ Horizontal timbers which form the lowest members of a frame supporting the superstructure of a building. | G. Utility Building |
| 8. _____ The slant of a rafter, it is the rise per foot of the run | H. Seat Cut |
| 9. _____ Vertical distance from top of wall plate to top of ridge board. | I. Rafters |
| 10. _____ Distance from outside of top wall plate on one exterior wall to outside of top wall plate on opposite wall. | J. Plate |
| 11. _____ The highest point of a roof composed of sloping sides. | K. Stud |
| 12. _____ the vertical cut at the top end of the rafter | L. Upper Plumb Cut |

Answer Sheet:

Unit Exam

1. G
2. I
3. H
4. F
5. K
6. J
7. A
8. C
9. B
10. D
11. E
12. L

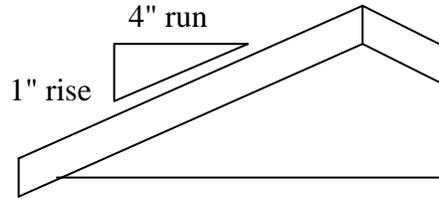
Worksheet, Rafter Cutting

1. Slope = $1/3$
2. Rafter Length = 37.95

CUTTING THE COMMON RAFTER

1. Determine the slope (Slope = inches of rise for each foot of run)

Examples: 1/4 slope = 3" of rise to 12" of run = $3/12 = 1/4$ or
 1/3 slope = 4" of rise to 12" of run
 1/2 slope = 6" of rise to 12" of run

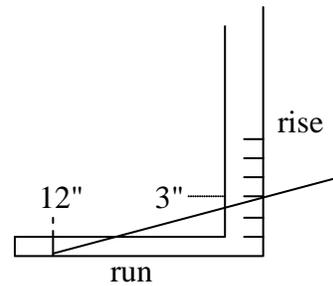


2. Determine the length (The length of the rafter is the hypotenuse of a right triangle)
 ($A^2 + B^2 = C^2$, $C^2 =$ the length of the rafter)

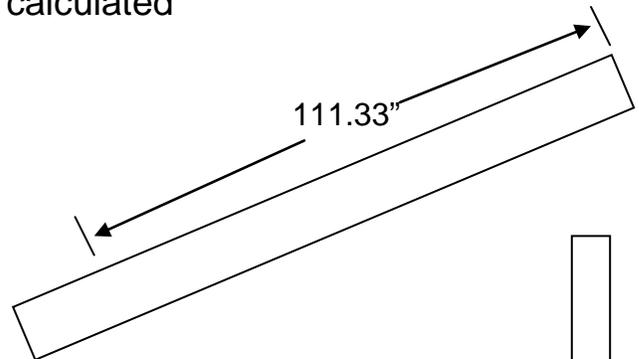
Example: A 1/4 slope with 9 feet of run = $108^2 + 27^2 = 111.32^2$ Rafter length = 111.32"
 ($9 * 12 = 108$ and $9 * 3 = 27$)

OR

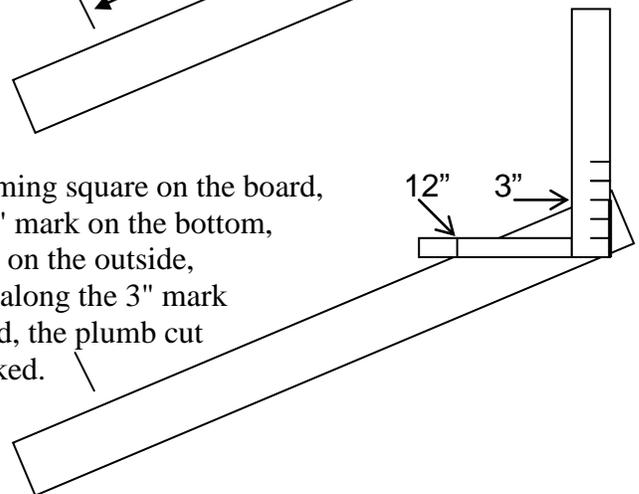
Using the Rafter table on a framing square,
 On the common rafter table, at the 3" mark you will see 12.37
 Remember 9 feet of run $9 * 12.37" = 111.33"$
 Rafter length = 111.33"
 Within one one-hundredth of each other is close enough



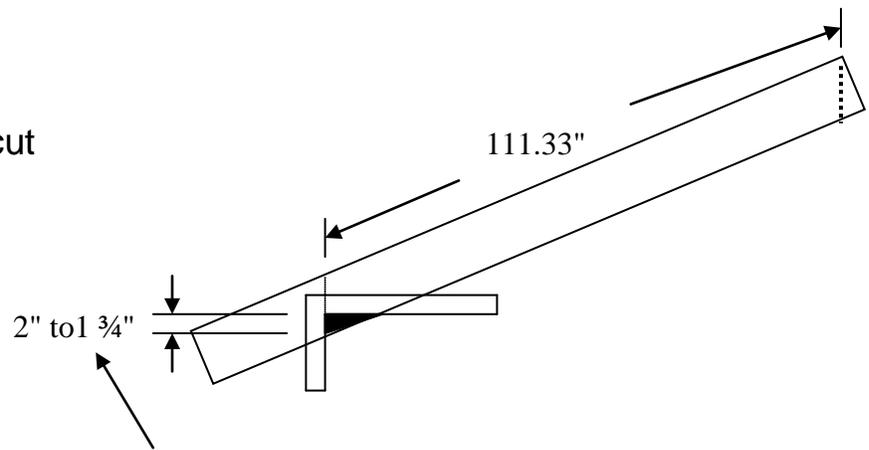
3. Mark off the length of the rafter as calculated



4. Mark out the plumb cut Lay the framing square on the board, with the 12" mark on the bottom, the 3" mark on the outside, draw a line along the 3" mark as illustrated, the plumb cut is now marked.

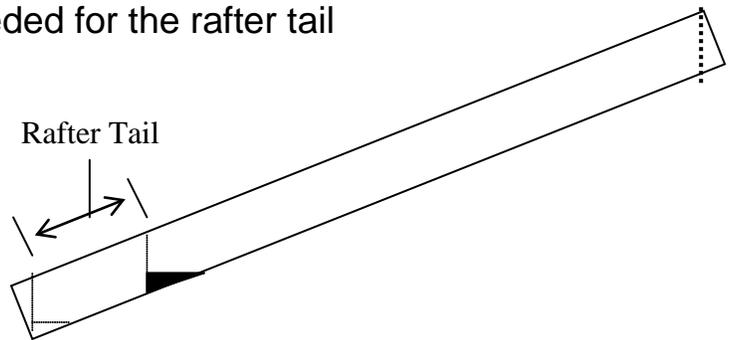


5. Mark out the seat cut

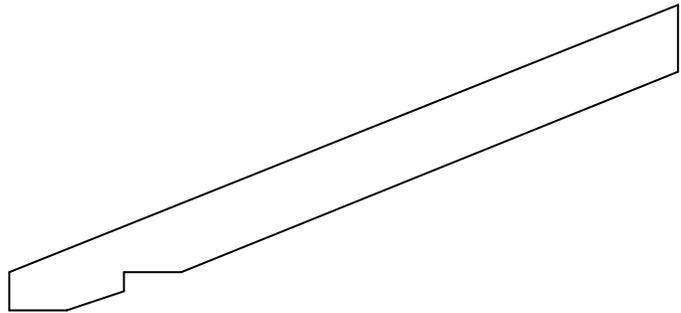


6. Make an allowance for the thickness of the ridge piece

7. Add the amount of stock needed for the rafter tail

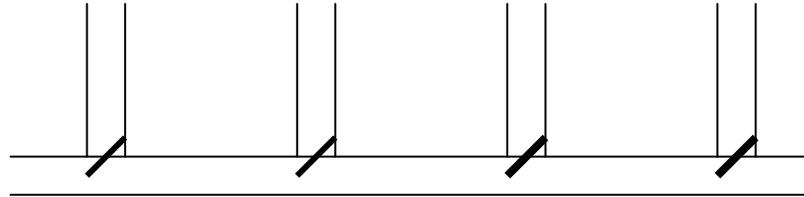


8. Cut the rafter and check the fit of the seat and plumb cuts

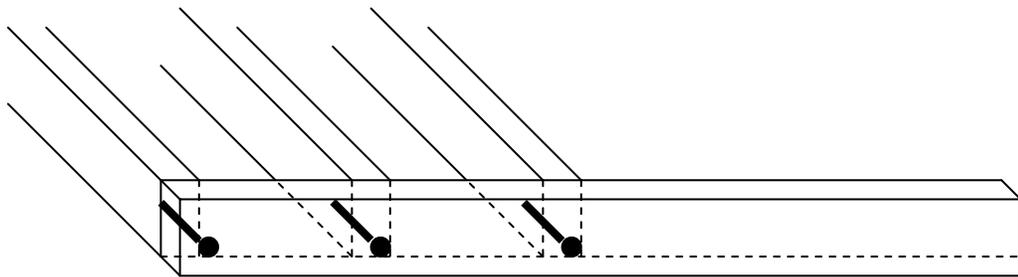


130P-17

NAILING



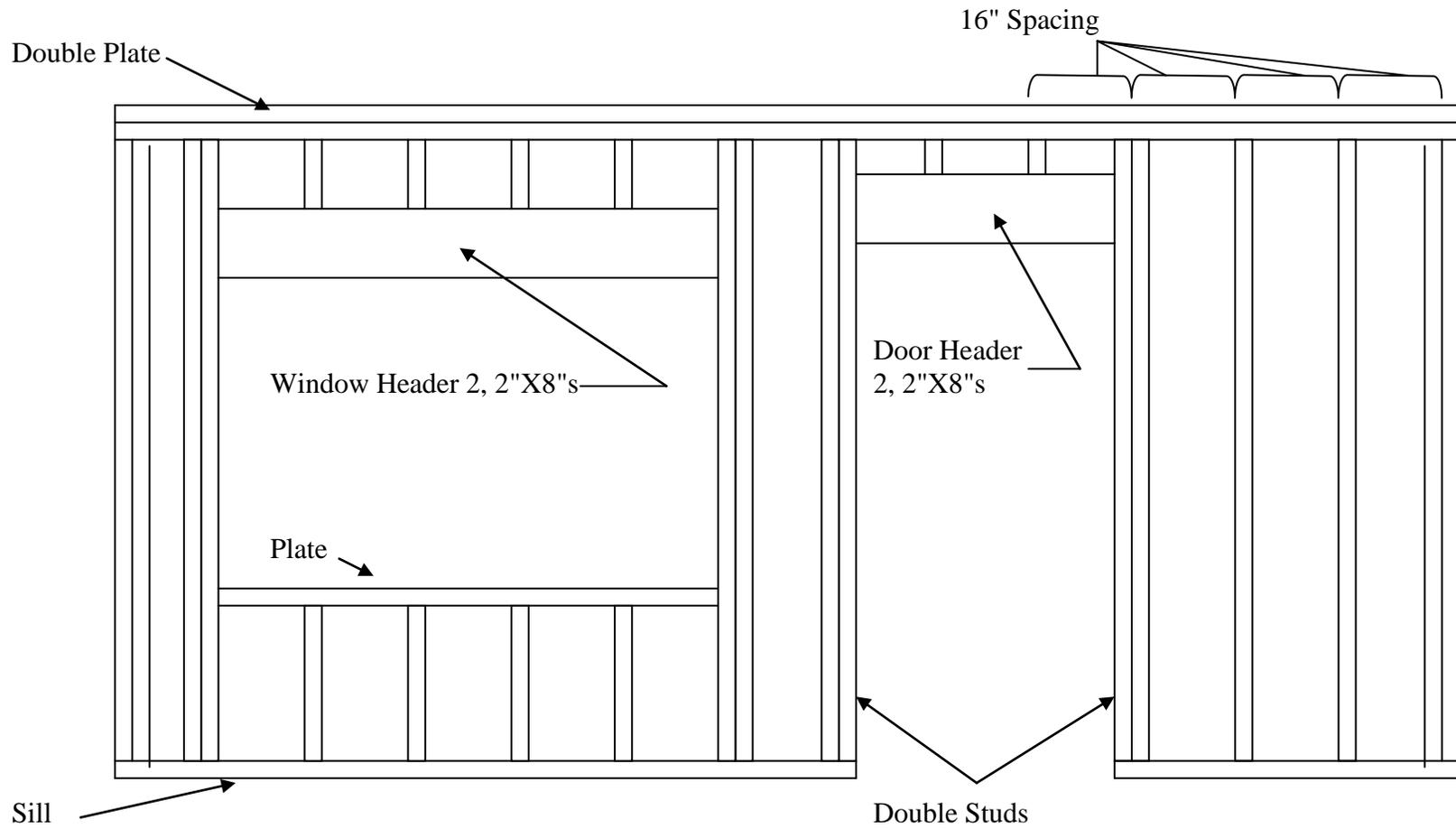
TOE-NAILING



END-NAILING

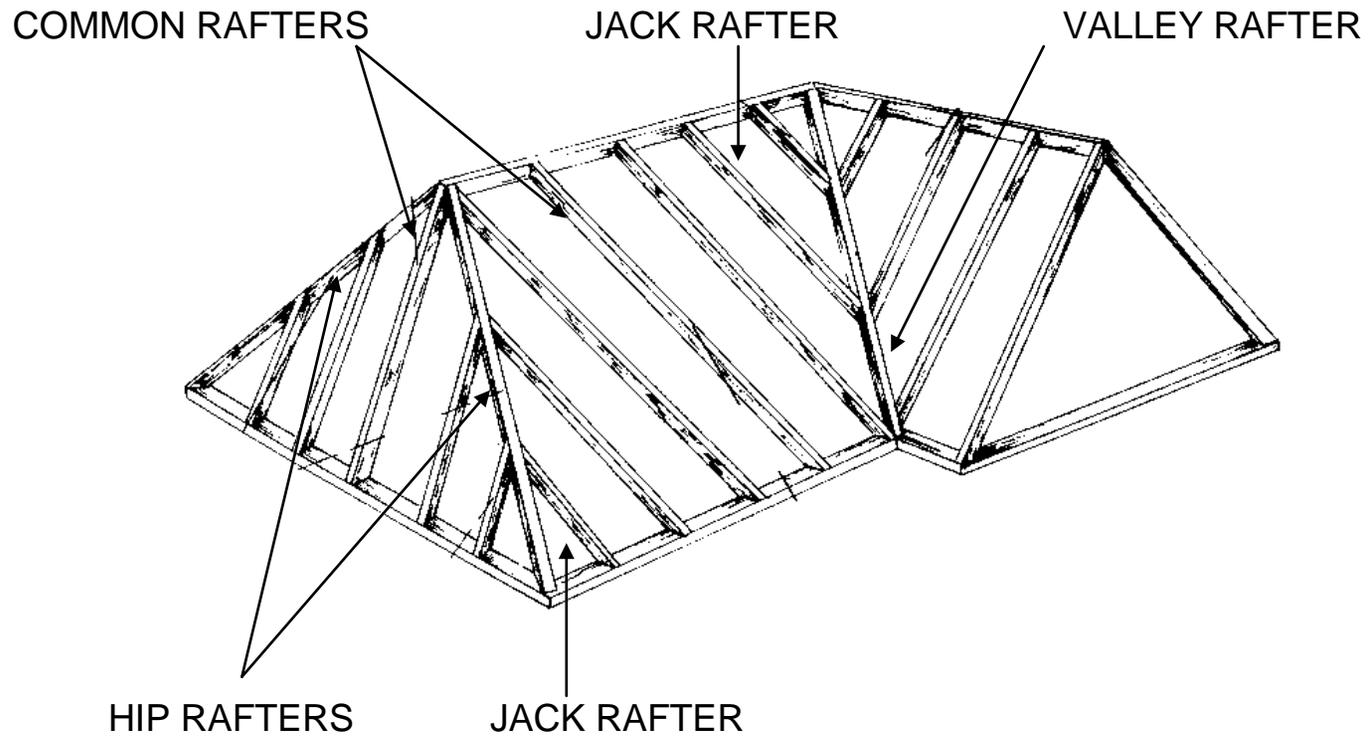
130P-18

FRAMING WALLS, WINDOWS & DOORS



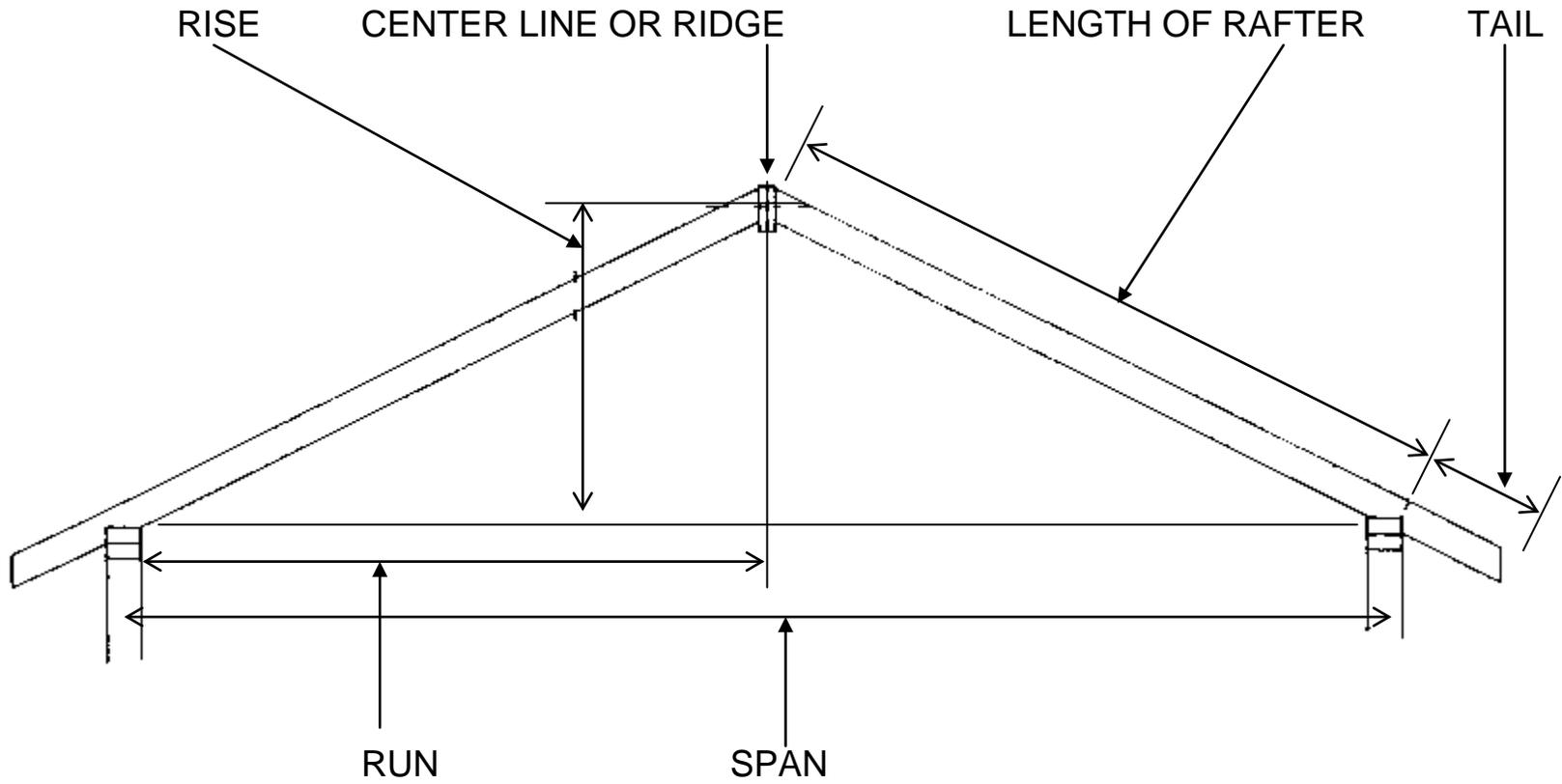
130P-19

TYPES OF RAFTERS



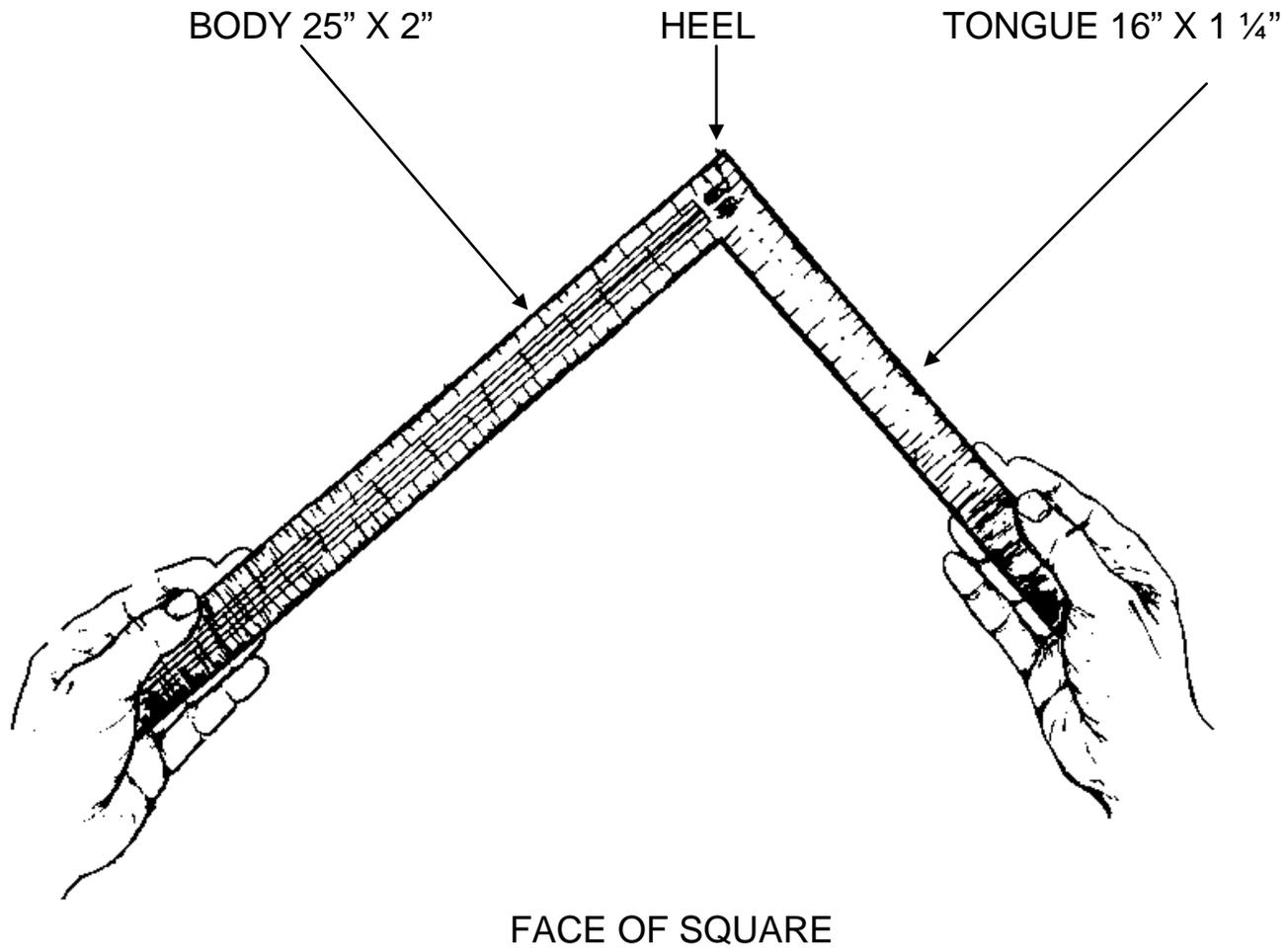
130P-20

PARTS OF A ROOF



130P-21

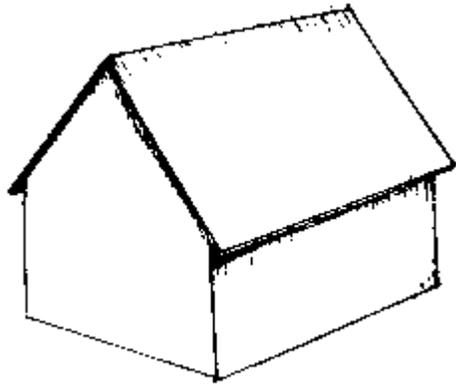
PARTS OF A FRAMING SQUARE



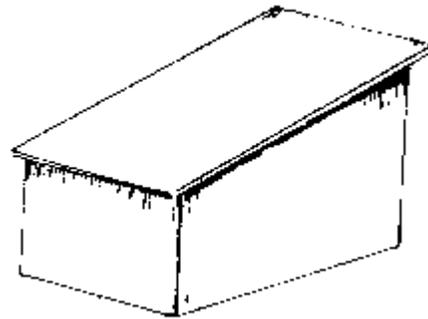
130P-22

TYPES OF ROOFS

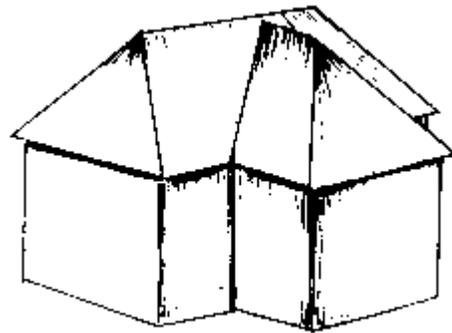
GABLE



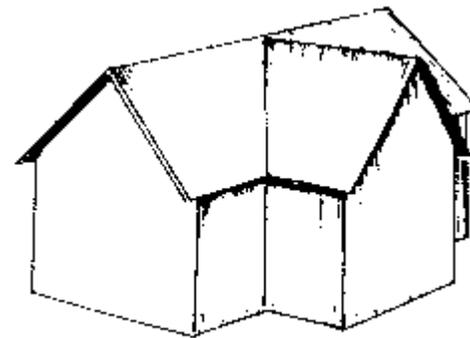
LEAN-TO



HIP



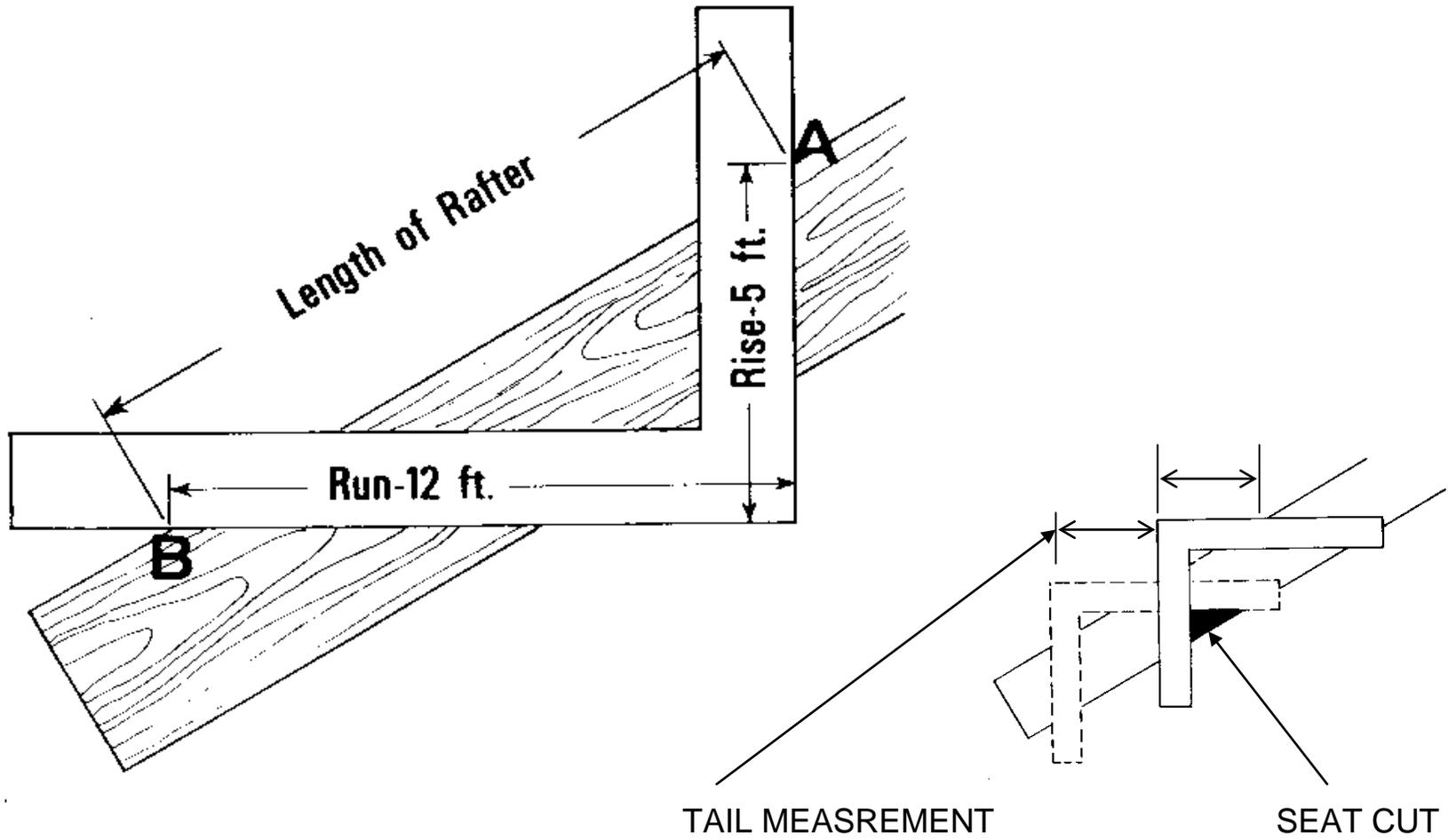
HIP AND VALLEY



GABLE AND VALLEY

130P-23

MARKING AND CUTTING A RAFTER



FRAMING SQUARE TABLES

RAFTER TABLE

BRACE TABLE

23	22	21	20	19	18	17	12	11	10	9	8	6	5	4
LENGTH COMMON RAFTERS PER FOOT RUN						15 97	16 28	15 62	15 00	14 42		13 42	13 00	12 63
HIP OR VALLEY						20 78	20 22	19 70	19 21	18 78		18 00	17 00	17 44
DIFF. IN LENGTH OF JACKS 16 INCHES CENTRES						22 625	21 704	20 83	20	19 23		17 875	17 33	16 87
2 FEET						33 94	32 56	31 24	30	28 84		28 83	26	25 30
SIDE CUT OF JACKS USE						8 1/2	8 7/8	9 1/4	9 5/8	10		10 3/4	11 1/6	11 3/8
HIP OR VALLEY USE						9 7/8	10 1/8	10 3/8	10 5/8	10 7/8		11 5/16	11 1/2	11 11/16
22	21	20	19	18	17		10	9	8	7	6	4	3	

8	7	6	5	4	3	2	1
3 44	4 8 67 88	5 1 72 17	6 4 76 37	7 7 80 61	8 0 84 85	9 3 88 10	
6	5	4	3	2	1		

1	2	3	4	5	6	7	8
1 8	2 1	3 5	4 9	5 14	6 18	7 23	8 28
1 6	2 6	3 6	4 7	5 8	6 9	7 10	8 11
1 50	2 9	3 6	4 7	5 8	6 9	7 10	8 11
2 2	3 1	4 1	5 2	6 3	7 4	8 5	9 6
2 4	3 8	4 4	5 10	6 6	7 12	8 8	9 14
2 6	3 10	4 6	5 12	6 8	7 14	8 10	9 16

ESSEX TABLE

130Q-1

INTRODUCTION TO ELECTRICITY

AG 130-Q

UNIT OBJECTIVE

After completion of this unit, students will be able to understand basic electricity, understand electrical measurements in watts, ampere, volts, and ohm. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Use approved safety measures in electrical wiring.
2. Select correct fuses & circuit breakers for a given circuit.
3. Select wire sizes for a given circuit.
4. Define ampere, watt, volt, and ohm
5. Exhibit safe habits when working around electricity.
6. Understand the difference between electrical flow of 240 volts and 120 volts in wiring.

PRINCIPLES OF ELECTRICITY

A. Basic Theory of Electricity

1. What is electricity?

- a. Electricity is the flow of electrons, through a conductor, from a positive to a negative charge.
- b. It can be generated, transmitted, and controlled.

2. Where does electricity come from?

- a. Electricity is present in all matter.
 - 1) All matter is made of combinations of elements called molecules, which are in turn made up of even smaller units called atoms.
 - 2) An atom is the smallest amount of an element that retains all the properties of the element.
 - 3) An atom may be broken down into smaller pieces whose relationships have been conceived of as a miniature solar system.
 - a) The center of the atom consists of protons, which carry a positive electrical charge, and neutrons, which carry no charge.
 - b) Electrons, which carry a negative electrical charge, orbit around the center of the atom.
 - c) Two kinds of electrons exist:
Planetary electrons cannot be readily moved from their orbits.
Free or valence electrons are loosely held in the atom's outer orbit and may drift into orbits of nearby atoms.
 - d) When an atom has an equal number of protons and electrons, it is said to be electrically neutral.

3. How is electric current produced?

- a. An atom becomes electrically charged when it has fewer electrons than protons.
- b. The random wandering of valence electrons from one atom to another does not produce any permanent changes.
- c. The overall material will remain the same if no outside influence disturbs the balance.

130Q-3

- d. If an outside force, such as a battery voltage, disturbs the balance, the loosely-held outer electrons will tend to move in one direction.
 - 1) When voltage is applied across the ends of a conductor, the electrons, which up to then had been moving in different directions, are forced to move in the same direction along the wire.
 - 2) The individual electrons all along the path are forced to leave their atom and travel a short distance to another atom that needs an electron.
 - 3) This motion of electrons is transmitted along the path from atom to atom, as the motion of a whip is transmitted from one end to the other.
- e. This nonrandom flow of electrons is called an electric current.
- f. When the free electrons move randomly, their energy is small, but when they are forced to move in the same direction, their collective energy is large and can be used for work.

B. Measuring Electric Current

1. Electron Flow (Amperage)

- a. An electric current is a flow of electrons along a conductor.
- b. The speed of this flow is nearly equal to the speed of light, 186,000 miles per second.
- c. The flow of electricity is measured by the number of electrons that pass a point in a wire in one second.
- d. An ampere is a measure of electron flow; it represents a flow of 1 coulomb of electricity (6.25×10^{18}) past a point in a wire in one second. Measured in a unit called amps and is abbreviated with the letter symbols I or A.
- e. Compared to a water system, an ampere would be similar to a measure of water flow through a pipe, such as gallons per minute.

2. Electromotive Force (Voltage)

- a. Electromotive (electron-moving) force or voltage is electrical potential which provides energy for the movement of electrons in a circuit.
- b. This electrical potential results from a difference in electron energies at two points in a circuit.

130Q-4

- c. This difference in electron energy levels in a circuit can be compared to the potential energy of water stored in a high water tower and the kinetic energy of water flowing through the pipe.
- d. Voltage is measured in units called volts (a difference variable) and is abbreviated with the letter symbols E or V.
- e. Compared to a water system, a volt would be similar to a measure of water pressure in a pipe, such as pounds per square inch.

3. Resistance to Current Flow (Resistance)

- a. Resistance is the ability of a material to resist electron flow.
- b. Materials vary in their number of valence electrons and in the ease with which electrons may be transferred between atoms.
- c. A conductor is a material through which electrons can flow freely.
- d. An insulator is a material that provides great resistance to electron flow.
- e. A semi-conductor is a material with poor conductivity and cannot be used as an insulator.
- f. Resistance is measured in units called ohms.
- g. The symbol for resistance is R, and the symbol for ohms is the Greek letter omega (Ω).

4. Energy (Reading The Meter – 130Q-23, Figures 4,5)

- a. Electrical energy is the amount of work that can be done by voltage and current over a specific period of time.
- b. The unit for measuring electrical energy is the watt-hour (more commonly specified as kilowatt hours which is 1000 watt hours); it is usually designated by the letters kWh.
- c. The mathematical relation between voltage, amperes, resistance, and electrical energy is:

$$1) \text{ kWh} = W \times T$$

Where,

W = Power (watts)

T = time (hours)

Example: The use of 1,000 watts for 5 hours =

$$\text{kWh} = 1,000 \text{ watts} \times \frac{1 \text{ kW}}{1,000 \text{ W}} \times 5 \text{ hrs} = 5 \text{ kWh}$$

130Q-5

5. Power

- a. Electrical power is the amount of work that can be done by voltage and current.
- b. The unit for measuring electrical power is the watt; it is usually designated by the letter W.
- c. A watt of power is equal to one volt pushing one ampere of current through a conductor with one ohm of resistance.
- d. The mathematical relation between power and voltage, resistance and amperes is:

$$1) W = A \times V$$

Where,

W = power (watts)

A = current (amperes)

V = electrical potential (volts)

e. Example of Usage

- 1) Most household/farm shop appliances and equipment are rated in watts (see the nameplate or manufacturer's specifications). Knowing the rating in watts and the voltage to be used (normally 120 or 240), the flow of current in the circuit for the appliance/equipment can be calculated.
- 2) You have purchased a 120 volt plug-in electric space heater for use in your shop. It is rated at 400 watts. How much current will the heater draw?

$$W = A \times V$$

Or,

$$A = W \text{ divided by } V$$

Where,

W = 400 watts

V = 120 volts

Therefore,

$$A = \frac{400W}{120V} = 3.33 \text{ A (amperes)}$$

130Q-6

f. The mathematical relation between power/watts and voltage, resistance and amperes can be rewritten as:

$$1) W = A \times V$$

And,

$$V = A \times R$$

Therefore,

$$W = A^2 \times R$$

C. Ohm's Law (Figure 130Q-1, Page 130Q-20)

1. The physicist, George Simon Ohm, discovered that the flow of electrical current through a conductor is directly proportional to the electromotive force that produces it and inversely proportional to the resistance in the conductor.
 - a. If the resistance to electron flow through an electrical device is cut in half, the current amperage doubles.
 - b. If the resistance remains constant, but the voltage is doubled, the current amperage doubles.
2. This relationship is expressed in Ohm's law as $E = IR$ or $V=AR$
 - a. I or A equals current in amperes.
 - b. E or V equals potential energy in volts.
 - c. R equals resistance in ohms.

D. Types of Electricity

1. Direct Current (DC)
 - a. Electrons flow constantly in one direction.
 - b. This is the type of electricity produced by all batteries.
2. Alternating Current (AC)
 - a. Electrons flow first in one direction and then in the reverse direction at a certain rate of reversal (cycles per second). (In the U.S., 60 cycles per second (60 Hertz) is the standard.)

130Q-7

- b. AC current has many advantages over DC, i.e., transformers to increase or decrease voltage can be used only with AC current.
- c. Transformers enable electricity to be carried long distances on small wires.

3. Single-Phase Current (Figure 130Q-2)

- a. This is the typical current supplied to households and businesses where power requirements are not very high.
- b. Single-phase current can be provided by two wires.

4. Three-phase Current (Figure 130Q-3)

- a. This type of current is designed especially for large electrical loads.
- b. It requires at least three wires.
- c. Three-phase current is actually three single-phase currents combined so that peak voltages are equally spaced.

E. Sources of Electricity

1. Friction

- a. An electrical charge is produced when certain materials are rubbed together. For example, walking across a carpeted floor or sliding across an automobile seat cover sometimes results in static electricity (buildup of electrical charge without current flow).
- b. Static electricity has little practical value; in fact, it tends to be a nuisance or a hazard.
Example: On January 27, 1967, astronauts Virgil Grissom, Edward White and Roger Chaffee entered the first Apollo capsule for a pre-flight test. All three were killed when a fire started by static electricity swept through the Apollo command module.

2. Heat

- a. If two dissimilar metals (for example, copper and constantan), are connected, and heat is applied at the junction, electrons will pass from one metal to the other.
- b. This is called the thermoelectric process.

130Q-8

- c. The thermoelectric process is used in furnaces to sense the presence of heat to hold open the fuel supply. When the furnace goes out, lack of heat causes the current flow to stop which in turn shuts off the fuel supply.

3. Light

- a. Some dissimilar materials have the property of producing electrical voltage when the boundary between them is subjected to light (radiant energy).
- b. These materials are said to be photovoltaic. Examples are cuprous oxide and copper or an electrode and an electrolyte.
- c. Photovoltaic materials are used in remote areas (communications satellites, etc.) where it would be impractical to run in lines or to provide batteries.

4. Pressure

- a. Some materials produce electricity when pressure is applied that changes their shape.
- b. These materials are said to be piezoelectric. Examples are quartz and Rochelle salt.
- c. Phonographs using a crystal cartridge utilize the piezoelectric principle to convert the movement of the needle to an electric signal which is then amplified and played through the speakers.

5. Chemical Action

a. Primary Cells

- 1) The combination of certain metals in an electrolyte solution will produce electricity, for example, copper and zinc in sulfuric acid.
- 2) Examples of batteries that produce electricity from primary cells are dry cell (paste-like electrolyte, carbon and zinc electrodes) and mercury batteries.
- 3) The zinc is used up, the electrons become balanced and the batteries go dead.

b. Storage Batteries

- 1) These batteries are similar to primary cells except that the process can be reversed and the battery can be recharged.

130Q-9

- 2) Examples of storage batteries are the lead-sulfuric acid batteries used in automobiles, tractors, etc. and the nickel-cadmium rechargeable batteries used in flashlights, radios, etc.

c. Fuel Cells

- 1) A container in which fuels react in the presence of an electrolyte and electrons are made available at the negative electrode terminal.
- 2) Oxygen and hydrogen are used as fuels in space vehicles to produce electricity.

6. Magnetic Action

- a. A flow of electrons is produced in a coil of wire which is moving within a magnetic field.
 - 1) The magnetic field can be provided by a stationary magnet.
 - 2) Movement of the wire can be provided by:
 - a. Falling water turning a turbine shaft
 - b) Atomic power producing steam which turns a turbine shaft
 - c) An internal combustion engine turning a shaft.
 - d) This is the most common method of producing electrical energy in large quantities to serve the home, farm, and business.

ELECTRICAL SAFETY

A. Electrical Hazards

1. Shock and fire are hazards associated with electric current.

a. Shock refers to the body's reaction to the passing of electrical current through it.

- 1) Shock occurs from a fall in blood pressure resulting in a decrease of blood supply, and therefore oxygen, to the brain.
- 2) The increasing levels of electrical shock caused by increasing amperage makes it clear that voltage is not the killer, rather amperage is.
- 3) Shock hazard from electrical current is expressed in milliamperes. One milliamper (commonly called a "milliamp") is equal to one thousandth of an ampere, i.e., $A/1000$ where A is the electrical current in amperes. The following gives an indication of the physical effects of current flow through the human body:

a) barely perceptible	2 milliamperes	0.002A
b) uncomfortable	5 milliamperes	0.005A
c) muscular freeze	10 milliamperes	0.010A
d) fatal	50 milliamperes	0.050A

b. Fire may occur when electrical conductors overheat or when a spark is produced when an electric current jumps an air gap between conductors.

2. Terminology Associated with Electrical Hazards

- a. A short is a direct connection between a hot wire and a ground connection, allowing amperage to flow up to the limits of a fuse or wire.
- b. A fault is a leakage of current (a high resistance connection) from a hot wire to a ground connection, which may be of such low amperage that the circuit protection will not trip.
- c. A Ground Fault Circuit Interruption (G.F.C.I.) is a device that measures fault current and automatically opens the circuit at a preset value, usually 5-7 milliamperes. The purpose is to protect people from fatal shock. GFCI should be installed where ever the potential for increased grounding exists such as bathrooms, kitchen counters, garage, or outdoor receptacles.

B. Protection of People and Property

1. General Safety Rules

- a. Follow the manufacturer's instructions for installation and use of all electrical equipment.
- b. Never disconnect or damage a electrical safety device that is provided by the manufacturer.
- c. Do not touch electrical appliances, boxes, or wiring with wet hands.
- d. Do not remove the long ground prong from three-prong 120-volt plugs.
- e. Discontinue using any extension cord that feels warm or smells like burning rubber.
- f. Do not use any switches, outlets, fixtures, or extension cords that are cracked or damaged in any way.
- g. Do not place extension cords under carpeting.
- h. If a fuse is blown or a breaker is tripped, find and correct the problem before installing a new fuse or resetting the breaker.
- i. Do not leave heat-producing appliances such as irons, hair dryers, and soldering irons unattended.
- j. Keep metal cases of electrical appliances grounded.
- k. Keep electrical motors lubricated and free of grease and dirt.
- l. If attempting to rescue a person being electrocuted, touch him only after the circuit has been opened, or use an insulated object to move him off the hot wire.

2. Safety Measures in Electrical Wiring

- a. Install all electrical wiring according to the National Electrical Code.
- b. Open the circuit before touching any point on the circuit.
- c. Do not touch bare wires with hands or tools while the circuit is closed.
- d. Do not touch wires together to see if they are hot.
- e. Do not touch switches or fixtures with wet hands or while standing on wet ground.
- f. Do not connect a new circuit to the breaker box until all the wiring is completed.
- g. Do not install fuses or breakers with an amperage larger than recommended, or they will not protect the circuit from overheating.
- h. Do not overload a circuit with too many fixtures and outlets.

130Q-12

- i. Use only double insulated portable tools or tools with three-prong plugs.
- j. Insulate splices with electricians' tape or solderless connectors.
- k. Install ground fault interrupters in kitchens, bathrooms, laundry, and outdoor circuits, or wherever moisture may increase shock hazard.
- l. Use proper color coding of wires when installing a new circuit.
- m. Have the local electrical inspector examine all wiring that you have installed.

3. Product Safety Testing

- a. Underwriters Laboratories (U.L.) test sample products, such as electrical appliances and tools, to see if they safely do the job for which they were designed.
- b. U. L. lists those products tested indicating that they have performed safely. It is not an endorsement or statement of quality.
- c. The manufacturers of these listed products display a U. L. label indicating that they have been tested.

SAFETY IN ELECTRICAL WORK

Observe the following general safety practices in doing all electrical work.

1. Avoid damp working areas. Never handle electrical equipment with wet hands or while standing in a wet or damp place.
2. Protect each circuit. Be certain that each circuit is protected with either a circuit breaker or a fuse of proper amperage.
3. Ground each circuit properly. Each circuit must have a ground (neutral) wire and a grounding wire to be properly grounded.
4. Use ground-fault circuit interrupters (GFCI's). To protect the operator who works outside or in damp locations, make sure the electrical source is protected by a ground-fault circuit interrupter.
5. Ground electrical equipment. All 120-volt electrical equipment should be equipped with a three-prong grounding-type plug or be double insulated. Never cut off a grounding prong just to make the connection work.
6. Disconnect the main switch. Before making any repairs on an electrical circuit, always make certain the current has been disconnected.
7. Correct the source of trouble. Before resetting circuit breakers or replacing blown fuses, correct the cause of the trouble. Repair or replace any equipment that gives a shock when it is used.

8. Purchase safe equipment. Select portable electrical equipment that is grounded with a three-prong plug or is double insulated. Look for the “UL” label, indicating that the equipment has been tested and approved by Underwriters Laboratories, Inc.
9. Review local electrical codes. When rewiring a building, follow the local electrical code.
10. Seek professional aid. Instead of using trial-and-error methods when electrical devices do not function properly, get professional help.
11. Avoid plumbing hazards. Do not locate switches or light fixtures near plumbing fixtures.
12. Inspect and repair cords periodically. Inspect all extension cords and electrical appliance cords periodically for exposed wires, faulty plugs, poor insulation, and loose connections. Correct all hazards found on electrical cords.
13. Open circuits with switches. Never pull a plug from an outlet while the equipment is in operation. This creates an arc and will eventually foul the plug or the outlet, which can cause electrical shock or a possible fire.
14. Never make temporary repairs. Make sure all repairs are as good as new. When splicing wires, be sure all strands are twisted together before soldering, the wires are parallel when using wire nuts, the connections are strong, and the splice is fully insulated.
15. Use electrical cords safely. Do not hang electrical cords on nails or run them under rugs or around pipes. Avoid using extension cords as permanent wiring installations.
16. Do not overload circuits. When new equipment is installed, make sure it is protected by a circuit of proper amperage rating.
17. Unplug electrical tools. Do not leave a tool plugged in when it is not in use, unless it is designed for continuous operation.

Reprinted by permission of Interstate Publishers, Inc., from MODERN AGRICULTURAL MECHANICS, 2nd ed., by Stanley R. Burke and T. J. Wakeman. Copyright 1992 by Interstate Publishers, Inc.

CONDUCTORS AND OVERCURRENT PROTECTION

A. Electrical Conductors

1. Fundamentals

- a. Conductors are materials that provide a good path for electron flow.
- b. Conductors used in wiring may be made of copper or aluminum.
 - 1) When the price of copper is high, aluminum may be used.
 - 2) Since aluminum is not as good a conductor as copper, it tends to build up more heat from resistance.
 - 3) Aluminum wire is commonly used for the service entrance but the ends of the wire are coated with an antioxidant paste.
- c. Conductors may be solid or made of many strands bundled together.
 - 1) Stranded wire, especially for wire sizes No. 8 and larger, improve flexibility and conductivity.
 - 2) Since electricity travels on the outer surface of wires, stranded wire increases conductivity by providing more total surface area.

2. Sizes of Conductors

- a. Conductors are classified into sizes by American Wire Gauge numbers.
- b. Common wire sizes run in even numbers from No. 18 to No. 6. The lower the gauge number, the larger the wire size.
- c. Commonly used wire gauge sizes and their ampere ratings for copper conductors are presented below.
 - 1) No. 14 is rated for 15-ampere circuits.
 - 2) No. 12 is rated for 20-ampere circuits.
 - 3) No. 10 is rated for 30-ampere circuits.
- d. Aluminum conductors require one wire size larger than copper conductors to provide the same amperage.

3. Types of Conductors

a. Electrical Wire

- 1) It is a single conductor.
- 2) It may be bare or insulated.
- 3) It is generally used for permanent installation in conduit or electrical metallic tubing.

b. Electrical Cable

- 1) It is a protective sheath containing two or more insulated wires.
- 2) It may contain a bare ground wire also.
- 3) It is generally used for permanent indoor installation.

c. Electrical Cord

- 1) It is a conductor consisting of two or more insulated, stranded wires.
- 2) It may have a ground wire.
- 3) It is generally used where flexibility is required.

B. Classification of Conductors According to Use

1. Types of Wires

a. Type R wire is insulated with rubber and is used for indoor installation.

- 1) Type RH is used in dry locations with high temperatures.
- 2) Type RHW is used in wet locations with high temperatures.

b. Type T wire is insulated with thermoplastic and is gradually replacing Type R wire.

- 1) Type T is used in dry locations.
- 2) Type TW is used in dry or wet locations.
- 3) Type THHN is used in dry locations with high temperatures.
- 4) Types THW and THWN are used in wet locations with high temperatures.

2. Types of Cables

a. Cable type markings indicate where the cable can be used.

- 1) Type USE is an underground cable which may be used for service feeders and branch circuits.
- 2) Type UF is an underground cable which may only be used for feeders and branch circuits.
- 3) Type NM is a moisture resistant, nonmetallic sheathed cable often referred to by the trade name, Romex and is only used indoors.
- 4) Type NMC is nonmetallic sheathed cable that is flame retardant and resistant to moisture, fungus, and corrosion.
- 5) Type SE is a service entrance cable used to carry current into a building. It is also used to serve welders and 220 volt appliances.

b. Other cable markings indicate the size and number of wires in a cable.

- 1) 12-2 indicates the cable has two No. 12 wires, one black and one white.
- 2) 12-2 w/g indicates the cable has two No. 12 wires plus a ground wire, one black, one white, and one green or bare.
- 3) 14-3 indicates the cable has three No. 14 wires, probably one black, one red, and one white.
- 4) 14-3 w/g indicates the cable has three No. 14 wires, the same as 14-3 cable with the addition of a green or bare ground wire.

3. Types of Cords

a. Parallel cords are commonly used on lamps, radios, clocks, etc. They are available in wire gauge sizes 16 and 18, and have a groove down the center to make separation of the two wires easy.

- 1) Type SP is insulated with rubber.
- 2) Type SPT is insulated with thermoplastic.

b. Junior hard-service cords are used on machines, power tools, trouble lamps, etc. They are round and available in wire gauge sizes 16 and 18.

130Q-17

- 1) Type SJ has rubber outer insulation.
 - 2) Type SJT has thermoplastic outer insulation.
 - 3) Type SJO has oil-resistant rubber outer insulation.
- c. Hard-service cords are used similarly to junior hard-service cords, but have a thicker outer cover for rough use. They are available in wire gauge sizes 10, 12, 14, 16, and 18.
- 1) Type S has rubber outer insulation.
 - 2) Type ST has thermoplastic outer insulation.
 - 3) Type SO has oil-resistant rubber outer insulation.
- d. Heater cords have two common types.
- 1) Type HPN has a thermosetting insulation that can be used in damp places, but is not designed for hard use. It comes in wire gauge sizes 12, 14, 16, and 18.
 - 2) Type HST has either a rubber and asbestos or neoprene insulation that can be used in damp places. It comes in wire gauge sizes 16 and 18.

C. Overcurrent Protection Devices

1. Fundamentals

- a. Each wire size is rated to safely carry a certain amount of electrical current.
- b. If wires carry current beyond their rated amperage, they will overheat, damaging insulation and a fire could result.
- c. Overcurrent protection devices are, therefore, necessary to protect the wires in an electrical system from excessive heat.

2. Fuses

- a. Fuses are overcurrent protection devices containing a strip of low-melting-temperature metal, called a link, which is designed to carry the amperage stamped on the fuse.
- b. When a circuit is overloaded, an excessive amount of current passes through the link causing it to melt, and thus opening the circuit before the wires are damaged.
- c. Two types of fuses are used, plugs and cartridges.
 - 1) Plug fuses are available in ordinary and time-delay types.

130Q-18

- a) Ordinary plug fuses range in size from 3 to 30 amperes and are used in circuits which do not have to handle the high starting current required by motors.
 - b) Time-delay plug fuses range in size from .4 to 30 amperes and are designed to carry temporary current overloads in electric motor circuits.
- 2) Cartridge fuses are used to protect circuit with ratings beyond 30 amperes and are also available in the ordinary and time-delay types.
- a) Ferrule cartridge fuses range in size up to 60 amperes.
 - b) Knife-blade contact, cartridge fuses are made in sizes higher than 60 amperes.

3. Circuit Breakers

- a. Circuit breakers are current overload protective devices that can be reset and used again after an overload.
- b. Breakers contain a metal alloy strip through which current must pass. This strip has calibrated amperage indicated on the breaker switch.
 - 1) Excessive heat from a current overload causes the strip to expand and change shape.
 - 2) This action trips the breaker switch opening the circuit.
- c. To function properly, the breaker amperage rating must never exceed the circuit amperage rating.
- d. Circuit breakers are time delayed, they can handle the extra current of a motor starting in the circuit without tripping.

ACTIVITY:

1. Pass written safety tests on electricity and keep them on file.
2. Observe a demonstration of first aid for electrical shock given by the local fire department.
3. Have each student complete a safety checklist of his or her own home's electrical system. The local fire department can provide a good checklist.
4. Measure amperage, voltage, and resistance with a volt-ohm-milliamperemeter (VOM).
5. Read a kilowatt-hour meter.
6. Work out problems using the formulas of electricity.

130Q-19

7. Identify the different types of fuses and circuit breakers.
8. Replace various fuses and reset a circuit breaker. Locate the emergency cutoff switches in the shop, push them, and reset the breaker to that circuit.
9. Identify the various wires, cables, and cords in the shop by reading their markings.
10. Take apart various electrical cables with a cable stripper.
11. Create a conductor display that can be used as a teaching aid.

Special Material and Equipment:

VOM meter

Samples of wires, cables, cords, fuses, breakers

References:

Cooper, E. L. (1997). *AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS*, 3ed EDITION. Albany, NY: Delmar Publishers.

Erpelding, L. H. (1971). *AGRIBUSINESS ELECTRICAL LESSON PLANS*. Danville, IL: Interstate Printers & Publishers.

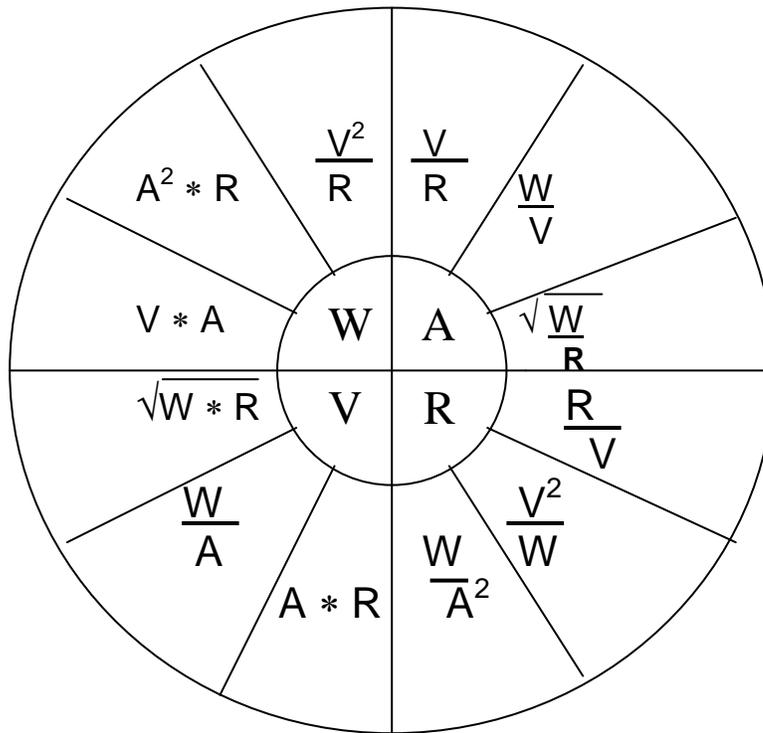
Gustafson, R. J. (1980). *FUNDAMENTALS OF ELECTRICITY FOR AGRICULTURE*. Westport, CT: AVI Publishing Company.

Singer, B. B. (1972). *BASIC MATHEMATICS FOR ELECTRICITY AND ELECTRONICS*. New York: McGraw-Hill.

NATIONAL ELECTRICAL CODE, 1999

Richter, H.P., Schwan, W.C. (1999). *WIRING SIMPLIFIED*, 39th EDITION. Minneapolis, MN: Park Publishing, INC.

Figure 130Q-1



Using amps and ohms to find voltage

Example: $20A \times 6R = \underline{120V}$

$4A \times 60R = \underline{240V}$

Using amps and watts to find voltage

Example: $1380W / 6A = \underline{230V}$

$715W / 6.5A = \underline{110V}$

Using volts and ohms to find amps

Example: $230V / 12R = \underline{19.2A}$

$110V / 11R = \underline{10A}$

Using watts and volts to find amps

Example: $6,000W / 120V = 50A$

$2640W / 240V = 11A$

Using volts and amps to find ohms

Example: $240V / 4A = 60R$

$24V / 9.6A = 2.5R$

Using volts and amps to find watts

Example: $240V \times 11A = 2640W$

$115V \times 6A = 690W$

Figure 130Q-2

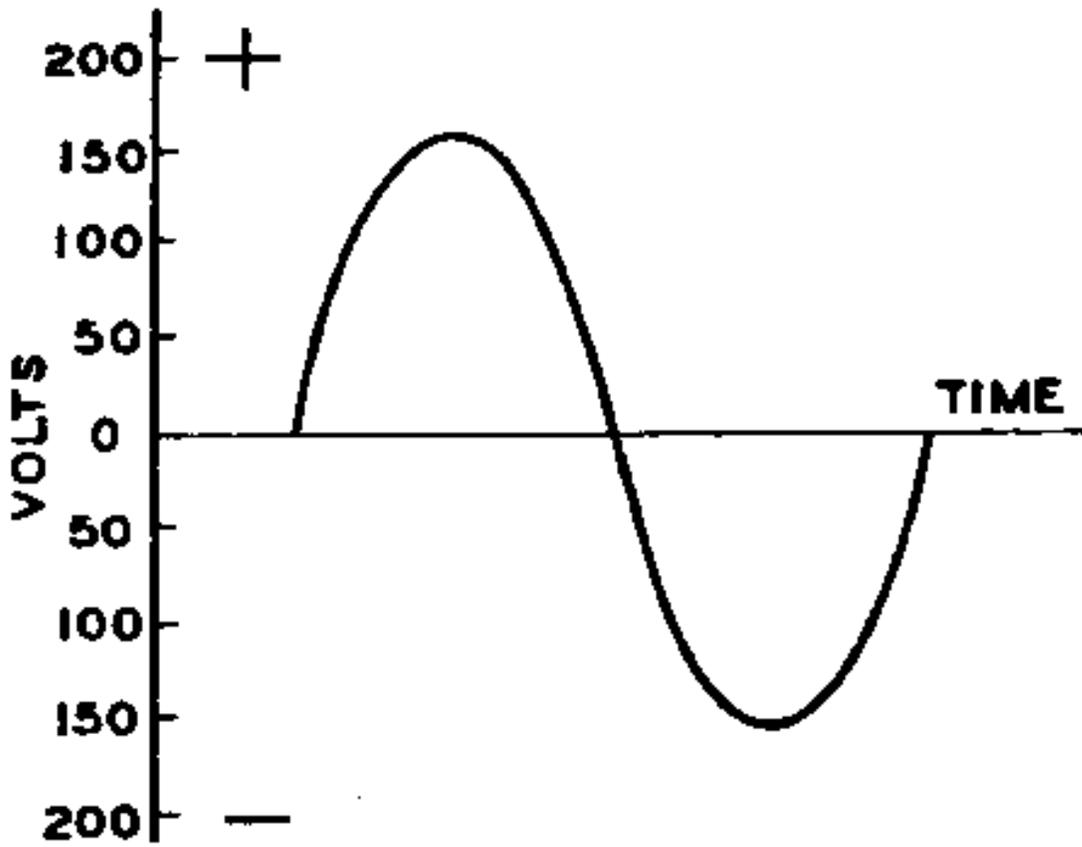


Figure 130Q-2 shows a single cycle of an alternating current

Figure 130Q-3

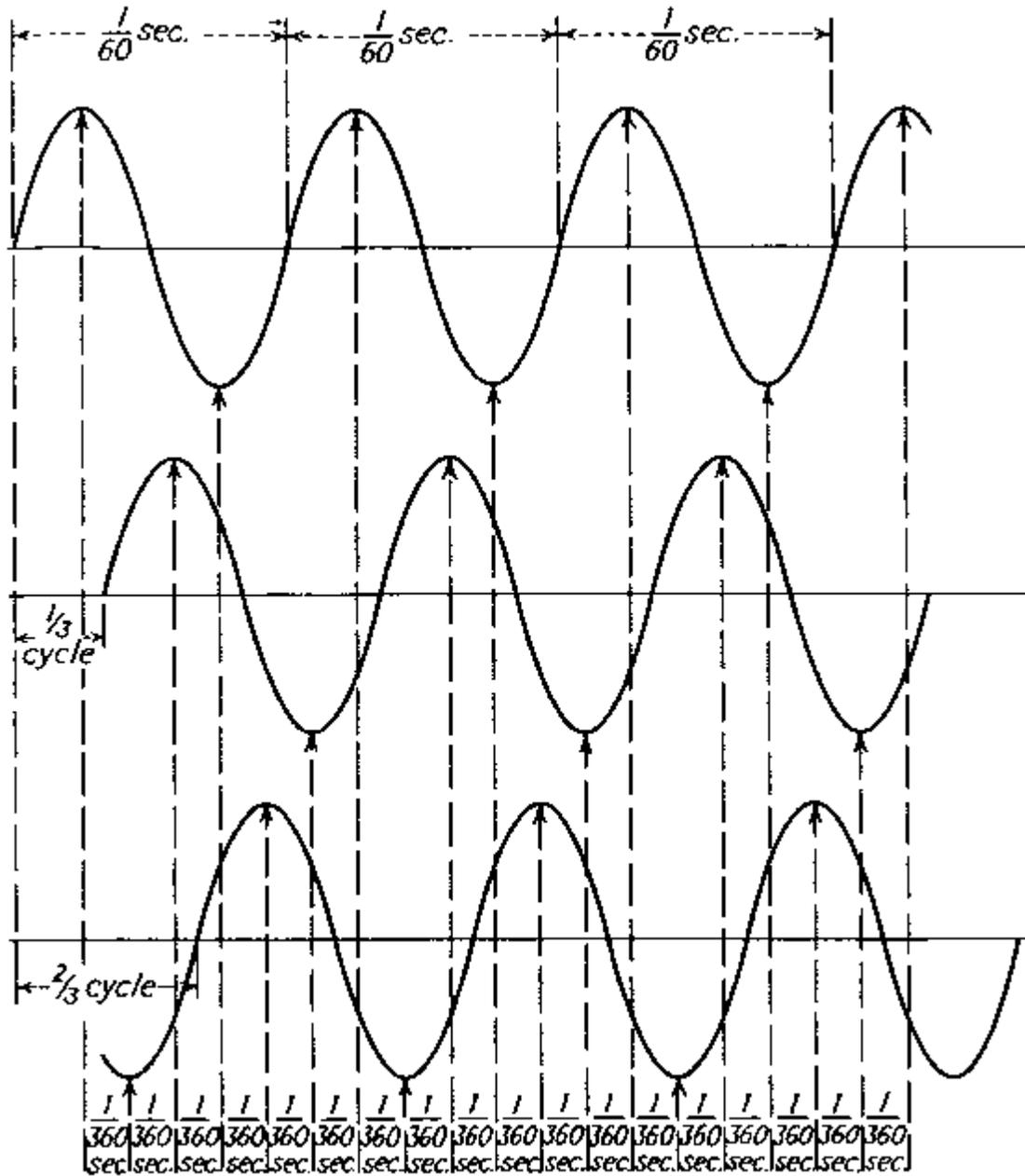


Figure 130Q-3 shows the three single cycles in three-phase electricity. When cycle A is at its' peak, cycle B is on its' way up and cycle C is almost at bottom. When cycle B is at its' peak, cycle C is on its' way up and cycle A is almost at bottom.

Name _____

Date _____

Score _____

Date Passed _____

ELECTRICAL SAFETY TEST

(Must pass with a grade of 90% or higher before working in the electrical lab.)

Questions 1 – 10 are true or false questions, circle T for true and F for false.

1. T or F Electrical cord can be placed under a rug for a short period of time.
2. T or F While not in use, electrical hand tools can be left plugged in.
3. T or F Under certain conditions an electrical shock from 115 volts can be fatal.
4. T or F Fires may occur when electrical conductors overheat, due to excess amps.
5. T or F A short is a direct connection between a hot wire and a ground or neutral connection.
6. T or F Do not do electrical work in damp or wet conditions.
7. T or F Do not install fuses or breakers with an amperage larger than recommended wire size.
8. T or F It's alright to use green wire for the power lead.
9. T or F Each convenient outlet needs to be properly grounded.
10. T or F Local electrical inspectors have the final say on new house and shop wiring in their district.

Short answer

11. What is the theory of electricity?
12. Do not connect a new circuit to the breaker box until _____?
13. At what amperage does muscular freeze occur?
14. Which is more dangerous, the voltage or the amperage.
15. When is horseplay allowed in the shop?
16. When can power tools be left plugged in over a long period of time?
17. When are temporary repair allowed?

READING THE METER

Reading the meter from left to right

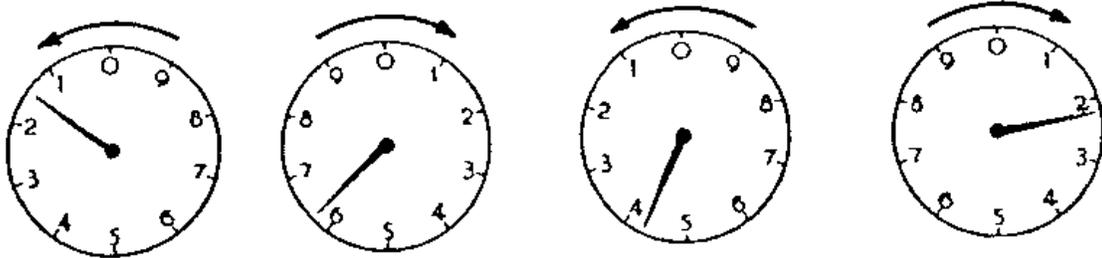


Figure 130Q-4 reads 1642 kWh

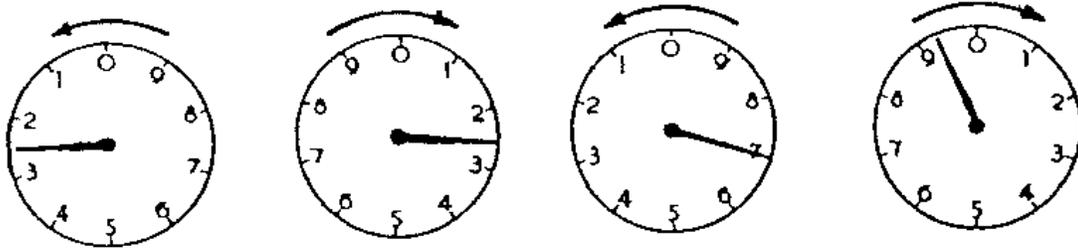


Figure 130Q-5 reads 2269 kWh

Step 1 Minus the first reading (1642 kWh) from the second reading taken a month later (2269 kWh), gives you the current kWh reading (627 kWh).

$$\begin{array}{r} 2269 \text{ kWh} \\ - 1642 \text{ kWh} \\ \hline 627 \text{ kWh} \end{array}$$

The average cost of electricity in Idaho is 5.5 cents per kWh

Step 2 Therefore, 627 kWh X 5.5 cents = 34.49\$

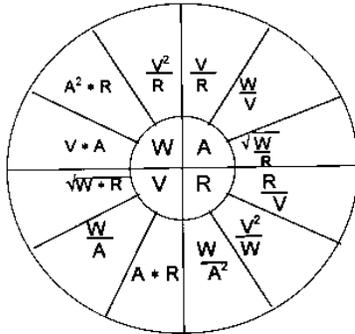
What would be the cost of operating a 1750W electric heater for 24 hours, if the cost of electricity is 5.5 cents per kWh. Assume the heater operates for 26 minutes an hour.

$$\text{Cost} = 1750\text{W} * 24\text{hr} * \frac{26\text{min}}{1\text{hr}} * \frac{1\text{hr}}{60\text{min}} * \frac{1\text{kW}}{1000\text{W}} * \frac{5.5\text{cents}}{\text{kWh}} = 100.1 \text{ cents or } \$1.00$$

Name _____

Date _____

Score _____



WORKSHEET, OHMS LAW AND POWER PROBLEMS

Using ohms law and the pie chart, answer the following questions. (SHOW YOUR WORK)

1. How many volts will be required to push 4 amps of current through a resistance of 12 ohms?
2. How many watts are produced from a heater which is drawing a current of 7 amps? The heater has a resistance of 11 ohms.
3. Find the current flow through a 25 ohm resistance if the source voltage across the resistance is 120 volts.
4. What size of resistance is required to produce 1500 watts with a current flow of 12 amps?
5. Find the voltage required to produce 500 watts through a 11-ohm resistance.
6. How much wattage is produced in a 5-ohm resistance if the voltage across the resistance is 120 volts?
7. How much current flow is required to produce 300 watts in a 20-ohm resistance.
8. What resistance will produce 1,000 watts of power when 120 volts is connected across the resistance?

ANSWER SHEET

Electrical Safety Test

1. F
2. F
3. T
4. T
5. T
6. T
7. T
8. F
9. T
10. T
11. The flow of electrons, through a conductor, from a positive to negative charge.
12. all wiring is completed.
13. 10 milliamps
14. Amperage
15. Never
16. Never
17. Never

Ohms Law (worksheet)

1. $4A \times 12R = 48V$
2. $7A^2 \times 11R = 539W$
3. $120V / 25R = 4.8A$
4. $1500W / 12A^2 = 10.4R$
5. $500W \times 11R = \sqrt{16500} = 74.2V$
6. $120V^2 \times 5R = 2,880W$
7. $300W / 20R = \sqrt{6000} = 3.88A$
8. $120V^2 / 1,000W = 14.4R$

130R-1

ELECTRICAL WIRING PRACTICES

AG 130-R

UNIT OBJECTIVE

After completion of this unit, students will be able to understand basic electricity, understand basic electrical repairs, and exhibit safe wiring habits when working around electricity. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Use approved safety measures in electrical wiring.
2. Make four different splices.
3. Repair an electrical cord.
4. Exhibit safe habits when working around electricity.
5. Complete wiring of light and convenience circuits.
6. Trouble shoot electrical circuits in a safe manner.

WIRE SPLICES

A. Wire Splicing Fundamentals

1. Definition of a Good Wire Splice

- a. A wire splice is one wire connected to another wire.
- b. The splice should be made so that it will conduct electricity as well as the unspliced wire.
- c. The insulation applied over the splice should also be just as good as the insulation on the unspliced wire.

2. Splice Standards in the National Electrical Code

- a. Connectors and splices must be enclosed in a junction box.
- b. All splices or connections must be soldered or fastened with a solderless connector.
- c. Splices with soldered connections must be wrapped with electrician's tape equivalent in an amount to the original insulation.

3. Cutting and Stripping Wires

- a. If a knife is used to remove the insulation from the wire to be spliced, make sure the knife is sharp.
- b. The knife blade should cut through the insulation at a 30-degree angle, and then moved parallel to the wire.
- c. The blade should not be held at a 90-degree angle to the wire and run around the wire, for this may nick the wire.
- d. The cut should leave the end of the insulation tapered.

4. Soldering Splices

- a. Solder needs flux to help it stick to copper wires.
 - 1) Resin is a good flux for electrical soldering.
 - 2) Acid fluxes should not be used, because they are corrosive.
- b. Use a resin-core, 50-50 (50% lead, 50% tin) solder that has a lower melting temperature than solder used in plumbing.
- c. Place the soldering gun or soldering iron directly against the bare splice joint, keeping the wire on top of the iron.

- d. When the wire is finally hot enough, apply the solder from above to the wire allowing it to flow into every opening between the turns of wire to insure good electrical conduction.

5. Replacing the Insulation with Plastic Electrician's Tape

- a. Place the tape over the tapered end of the insulation and wind it spirally to the other end, allowing the turns to overlap a little.
- b. Keep the tape tight so it will come together and seal out moisture and dirt.
- c. Apply as many layers of tape as needed to build up the insulation to match what was taken off.

B. Four Common Wire Splices

1. End Splice (Western Union Splice)

- a. The end splice is the most common type of small wire splice and is used to join two wires together so that the splice is as strong as the unspliced wire.
- b. The end splice can be completed in six easy steps:
 - 1) Remove about three inches of insulation from the ends of the two wires. Remember to make a tapering cut on the insulation.
 - 2) Clean the exposed wire by scraping or sandpapering.
 - 3) Halfway down the length of its exposed section, bend each wire 90 degrees and hook the two together at the bends.
 - 4) Holding the wires securely with a pair of pliers, twist them in opposite directions around each other. Make sure the ends of the wires are wrapped as tight as possible so their sharp points will not cut through the tape insulation applied later.
 - 5) Solder the splice to insure proper conduction of electricity.
 - 6) Properly insulate the splice with electrical tape.

2. Tap or Branch Splice

- a. A tap splice is used when one wire must be tapped into another wire somewhere other than its end.
- b. The tap splice can be completed in six easy steps:

130R-4

- 1) Remove at least two inches of insulation from the wire to which the tap is to be made.
- 2) Remove at least three inches of insulation from the end of the tap wire.
- 3) Clean the exposed wire by scraping or sandpapering.
- 4) Cross the wires holding them securely while the tap wire is wrapped tightly around the bare section of the other wire.
- 5) Solder the splice to insure proper conduction of electricity.
- 6) Properly insulate the splice with electrical tape.

3. Rat-tail Splice

- a. The rat-tail splice is used on joints where there will be no strain on the wires, such as connecting wires in lighting fixtures, outlet boxes, and junction boxes.
- b. A rat-tail splice can be completed in six easy steps:
 - 1) Remove about two inches of insulation from the ends of the two wires to be spliced.
 - 2) Clean the exposed wires by scraping or sandpapering.
 - 3) Cross the wires holding them securely with a pair of pliers and twist them together.
 - 4) Fold the sharp wire ends back along the twist to prevent a sharp point from cutting through the insulation tape.
 - 5) Solder the splice or use a twist on solderless connector (which provides its own insulation) to insure proper conduction of electricity.
 - 6) Properly insulate the splice if it is soldered.

4. Two-Conductor Cord Splice

- a. This splice uses two staggered end splices to join twin conductors together.
- b. It can be completed in six easy steps:
 - 1) Remove about six inches of insulation from each end of the two conductors.
 - 2) Clean the exposed wire by scraping or sandpapering.
 - 3) Make two staggered end splices, one for each conductor.

130R-5

- a) The splices are staggered so that each splice is made alongside the insulation on the parallel conductor.
 - b) If the splices are made side by side, there would be the danger of a short, and the splice would be bulky.
 - c) Stagger the splices by cutting one wire of each set of conductors, three inches shorter than its parallel wire.
 - d) When making the splice, match the short end of one wire with the long end of the other conductor and join them.
- 4) Solder the splice to insure proper conduction of electricity.
 - 5) Properly insulate the splice with electrician's tape.

ELECTRICAL CORD REPAIR

A. Electrical Cord Failure

1. Causes of Electrical Cord Failure

- a. Electrical cords usually consist of an attachment plug and a two- or three-wire insulated conductor.
- b. These wires are made of many fine strands of wire in order to make the cord flexible.
- c. If these fine strands of wire are flexed too many times or become mechanically damaged, they will eventually break.
- d. The cord's insulation will eventually break down from exposure to too much sunlight and heat.

2. Types of Electrical Cords and their Most Common Damage

a. Heater Cords

- 1) Heater cords are found on many tools such as branding irons, dehorning irons, soldering irons, and space heaters.
- 2) Intense heat and frequent use are the main causes of heater cord failure.

130R-6

b. Service Cords

- 1) Service cords are found on lamps, power tools, and motors.
- 2) Service cord failure is due primarily to being flexed too many times or being coiled too tightly around a warm machine.
- 3) Most of the damage occurs near the attachment plug or where the cord enters the machine.

c. Extension Cords

- 1) Extension cords are used extensively in agriculture to provide a temporary, flexible extension of an electrical circuit.
- 2) Extension cord failure occurs primarily from insulation and plug damage.

B. Repair Procedures

1. Removing a Plug from a Cord

- a. Remove the cord from the tool or motor and the convenience outlet.
- b. Remove the screws holding the plug together and open the shell slowly, observing the position of the wires and terminal clips.
- c. Push the cord protector back over the cord.
- d. Loosen the screws on the terminal clips and remove the wires.
- e. Examine the plug body and terminal clips for damage.
 - 1) A burned, discolored, broken, or cracked plug body should be replaced.
 - 2) Terminal clips that have lost their spring due to heat should be replaced because they will make poor contact.

2. Repairing the Cord

- a. Remove all the burned, charred, brittle, or discolored insulation.
 - 1) Cut the cord back to the point where the insulation of the wires is good.
 - 2) Make sure that the wires are cut to the same length.

130R-7

- b. Remove the appropriate amount of outer cord jacket by placing the ends of the wires in the plug channels to determine how much.
- c. Remove the insulation from the individual wire ends just enough to hook around the terminal screws.
- d. Clean the bare wires of any foreign material by scraping and then twist the strands together tightly.

3. Attaching a Plug to a Cord

- a. Tie a holding knot (the Underwriters' knot) in the exposed, insulated wires where they extend from the outer cover.
- b. Loop the bare ends of the wires so they may be properly attached to the screw terminal clips.
- c. Wrap the wires around behind the prongs to better withstand pulls on the cord.
- d. Place the looped wire end well under the screw heads and avoid fraying when tightening the screws.
- e. Place each screw terminal clip in its proper position in the plug.
- f. Replace the cord protector in the appropriate slot in the plug.
- g. Replace the other half of the plug slowly.
- h. Replace the screws that hold the plug together.

4. Attaching a Lamp Socket to a Cord

- a. Remove the cap from the socket, usually by pressing at a designated point on the socket and prying.
- b. Insert the end of the cord through the cap and tie the holding knot.
- c. Strip the insulation from the ends of the wires and attach them to the terminal screws without fraying the wires.
- d. Replace the cap onto the socket, making sure that the insulating bushing in the top of the cap and the insulation inside the shell are both in good condition and in place.

SIMPLE CIRCUIT INSTALLATION

A. Fundamentals of Electric Circuits

1. Circuit Terms

- a. Simple Circuit -- A simple circuit is a complete circle of current flow. It consists of a source of electricity, one wire to carry the current from the source to where it will be used, and another wire to carry it back, plus an object of rated resistance (for example, a lamp) to use the voltage.
- b. Branch circuit--Branch circuits are circuits beginning from the service entrance panel and branching out into a variety of places for a variety of purposes.
- c. Open circuit--An open circuit refers to a break in the circuit circle so that the current cannot flow through it.
- d. Short circuit--A short circuit is a current flow around the circuit resistance and back to the source so rapidly that fuses blow, wire insulation burns, and batteries drain.
- e. Grounding--Grounding is the practice of providing an additional connection between a piece of electrical equipment and the earth with a conductor called a ground wire in case the current gets out of the circuit.

2. Components of a Simple Two-wire Circuit

- a. Wires--A simple circuit has a white wire and a black wire.
 - 1) The white wire is known as the neutral or grounded wire because it is always connected to an underground water pipe or a ground rod through the service-entrance panel.
 - a) It must always run direct to every 120-volt outlet.
 - b) It must always be connected to a neutral terminal (silver-colored).
 - c) It never has a fuse or breaker.
 - d) It never has a switch.
 - e) It must be electrically continuous.
 - 2) The black wire is referred to as the "hot" wire.
 - a) One black wire and one white wire must run to every outlet.

b) Electrical potential always exists between the black wire and the white wire.

b. Electrical Boxes--These are boxes made of either metal or plastic, rectangular or octagonal in shape, which have the following functions:

- 1) They anchor the cable or conduit so stress cannot be placed on wire connections.
- 2) They are nailed, screwed, or clamped to the building in order to support outlets, switches, or fixtures.
- 3) They contain all wire connections made outside of fixtures.

c. Outlets--The most common outlet is the duplex receptacle wired so that both of its outlets are on the same circuit.

- 1) Outlets are wired across the black wire and the white wire.
- 2) The current enters the outlet on the black wire, flows from one screw through a metal strap to the other screw, and continues on to the next electrical box.
- 3) One outlet in a duplex receptacle may be switched by breaking the metal strap between the two screws, but they must be on the same circuit breaker.

d. Fixtures--They are bases or housings for light bulbs, fan motors, and other such electrical devices.

e. Switches--They are electrical devices which provide a means to open a circuit to stop electron flow to outlets or lights and to close it again to allow current flow.

- 1) The wire is usually black except in a switch loop.
- 2) Their amperage and voltage ratings must match those of the circuit.
- 3) Their number of poles indicates how many hot wires feed through the switch.
- 4) Their number of throws indicates from how many locations a switch can be operated.

f. Overcurrent Protection Devices--Fuses and breakers are always wired to the black (hot) wire.

g. Entrance Switch--It is a switch placed ahead of the fuse in the hot wire where electricity enters the building.

3. Colors of Wires and Terminals in Structural Wiring

a. Colors of Wires

- 1) White (sometimes natural gray) colored wire must be used only for the ground wire.
- 2) Additional grounding conductors may be green, green with one or more yellow stripes, or a bare wire.
- 3) Wiring for the "hot" wires may be any other color but it is most frequently black or red.
- 4) The color schemes most often used for structural wiring are:
 - a) Two wire circuit - white and black
 - b) Three wire circuit - white, black, and red
 - c) Four wire circuit - white, black, red, and blue
 - d) Five wire circuit - white, black, red, blue, and yellow

b. Colors of Terminals on Electrical Equipment

- 1) Natural copper or brass terminals are for "hot" wires only.
- 2) Terminals of a whitish color (such as nickel, tin, or zinc-plated) are for grounded wires only.
- 3) Terminals of a green color are for grounding wires only.
 - a) Grounding wires are those connected to the surface or shell of an appliance or tool to supply a continuous low resistance path to ground should the surface of the tool or appliance accidentally become energized

B. Wiring a Convenience Circuit

1. Wiring Boxes with 12-2 G Romex Cable:

- a. Fasten the boxes securely to the framing.
- b. Drill holes in the framing through which the cable is to be pulled.
- c. Run the cable between the boxes and secure them with staples within 12 inches of the boxes.

- d. Prepare the cable for insertion into the boxes by slitting 6 to 8 inches of the outside cable covering (jacket) with a knife or cable ripper.
- e. Separate the wires from the ripped jacket and cut off the excess jacket material.
- f. Insert the ends of each cable through a knockout hole in a box leaving six inches extending from the box.
- g. Tighten the cable clamp to secure the cable to the box with 1/16 inch of the cable jacket extending into the box beyond the clamp.

2. Wiring a Duplex Receptacle

- a. Remove about 3/4 inch of insulation from the ends of the black and white wires extending from the box. Use a knife or wire stripper, but do not nick the wires.
- b. Make a round loop in the end of each wire with needle-nose pliers.
- c. Wrap the loops of the black wires around the brass colored screws of the receptacle in the direction the screw turns, and then tighten the screws.
- d. Wrap the loops of the white wires around the silver colored screws of the receptacle in the direction the screw turns, and then tighten the screws.
- e. Wrap the loop of the bare wire around the green screw of the receptacle in the direction the screw turns, and then tighten the screw.
- f. If a second bare wire from another cable is in the same box, secure it to the other bare wire with a special metal crimp clamp or a solderless connector.
- g. Secure the receptacle with the screws provided and install the receptacle box cover.

C. Wiring a Light Circuit

1. Wiring a Light Fixture Between the Source and the Switch

- a. Strip 5/8 inch insulation from the ends of all the wires in the octagonal junction box to prepare them for connection with wire nuts (solderless connectors).
- b. Strip 5/8 inch of insulation from both ends of an 8-inch length of green wire and ground it to the box with a ground screw.

- c. Bundle the four ground wires together and twist a wire nut onto the four wire ends.
- d. Mark the white wire coming from the switch with black tape to identify it as a hot wire.
- e. Attach the black wire from the switch to the brass colored terminal of the light fixture.
- f. Strip 5/8 inch of insulation from both ends of an 8-inch length of white wire and attach one end to the silver colored screw of the light fixture.
- g. Connect the loose ends of the three white wires with a wire nut.
- h. Connect the ends of the remaining black wires--including the white wire wrapped in black tape--with a wire nut.

2. Wiring a Single Pole, Single Throw Switch for the Light Above

- a. Remove about 3/4 inch of insulation from the ends of the black and white wires running to the switch from the light.
- b. Make a round loop in the end of each wire with needle-nose pliers.
- c. Wrap black tape around the white wire to identify it as a black or hot wire.
- d. Wrap the loops of the black wires around the brass colored screws of the receptacle in the direction the screw turns, and then tighten the screws.
- e. Attach the bare ground wire to the box with a ground screw.
- f. Secure the switch in the box with screws provided and install the switch cover.

TESTING ELECTRIC CIRCUITS

A. Types of Electrical Circuit Testers

1. There are two general types of electrical test meters:
 - a. Digital - Meter displays numbers when measuring volts, ohms, amperes, or other electrical measurements.
 - b. Analog - Meter uses a needle to indicate measurement reading of volts, ohms, amperes, or other electrical measurements.

2. Types of Electrical Test Devices

a. Ammeter

- 1) Measures the flow of current in an electrical circuit.
- 2) Units of measurement are amperes or milliamperes (milliamps).
- 3) The meter must be installed in the circuit in series in order to measure current properly.
- 4) Clamp over ammeters are also available.

b. Voltmeter

- 1) Measures the potential of electricity in a circuit.
- 2) Units of measurement are volts.
- 3) The meter must be installed in the circuit in parallel in order to measure voltage properly.

c. Ohmmeter

- 1) Measures the resistance of a circuit component or circuit section.
- 2) Units of measurement are ohms.
- 3) The meter must be installed in the circuit in parallel across the component or circuit section for which the resistance is to be measured. For accurate reading, remove the component from the circuit and measure.
- 4) It is important that the circuit not be energized (i.e., no current should be flowing through the circuit) when the measurement is being made.
- 5) An ohmmeter should be calibrated with each use and with each change of meter scale.

d. Multitester

- 1) A meter with variable scales capable of measuring volts and ohms and additionally giving an audible indication of circuit continuity.

e. Multimeter

- 1) A meter with variable scales capable of measuring volts, ohms, and milliamperes and additionally giving an audible indication of circuit continuity.

f. Test Light

- 1) A light bulb with two wires attached can serve as a test light.
- 2) It can be used to troubleshoot circuits for shorts, opens, grounds, and voltage.
- 3) When connected in series in a circuit, the light bulb lights to indicate presence of current.

g. Continuity Test Light

- 1) This is similar to a test light except that it contains a battery along with a light bulb.
- 2) It can be used to troubleshoot circuits for shorts, opens, grounds, and voltage.
- 3) The continuity test light will "light" whenever it is connected to both ends of a circuit wire that has "continuity," i.e., is not broken.

h. Three-prong Circuit Tester

- 1) This is a commercially available device that plugs into the outlet of the circuit.
- 2) A three-prong circuit tester indicates:
 - a) Correct wiring
 - b) Open ground
 - c) Reverse polarity
 - d) Open neutral
 - e) Hot and ground wire reversed

B. Troubleshooting Electric Circuits with a Test Light

1. Short Circuits

- a. A short circuit occurs when direct contact is made between the two wires of a circuit or some other part which is conducting electricity as a result of damage or failure of the insulation.
- b. When a short circuit occurs, the fuse or circuit breaker will open the circuit.
- c. An ohms meter or a test light can be used to locate short circuits.

2. Open Circuits

- a. Sometimes "opens" or breaks in electrical connections in appliances will occur. These most generally occur in the cord near a point where the cord enters the electrical device.
- b. When an open occurs, the machine or appliance will not operate. However, before assuming the problem is an open, check to make sure that the attachment plug is making good contact with the convenience outlet.
- c. The test lamp may be used to locate opens.
 - 1) Connect the clips on the test lamp to the terminals of the electrical device. Most likely the casing or a portion of it will have to be removed from the device.
 - 2) Plug the attachment cord on the test lamp into a convenience outlet and turn the appliance on. If the device operates, the open exists in the service cord. If, it still does not operate, the open is in the switch or some other part of the device.

3. Accidental Grounds

- a. An accidental ground or grounding fault can occur when insulation becomes damaged or is removed by some cause. The conductor can then electrically charge that with which it makes contact. If a person touches the electrically charged part, the electron flow travels through him to the ground.
- b. To prevent accidental grounds, manufacturers often attach a ground wire to the frames of tools, appliances, and machines. If the frame is accidentally charged, the electron flow will travel to the ground through the ground wire.
- c. The test lamp may be used to check for accidental grounds.
 - 1) Disconnect the device being tested and insulate it from the ground.
 - 2) Attach one of the clips on the test lamp to one of the flat prongs (not the round prong) on the attachment plug of the device being tested and the other clip to the frame of the device.
 - 3) Plug in the test lamp. If the bulb glows, the frame of the appliance is electrically charged and can cause a serious accident.

130R-16

- 4) Each appliance that has been repaired should be checked for accidental grounds before being returned to the owner or to use.

4. The test lamp may be used for other purposes.

- a. The test lamp may be used to determine whether an outlet is 120 or 240 volts. The 240-volt lamp in the test lamp will glow brightly if the circuit is 240 and dimly if 120.
- b. The test lamp can be used to determine whether an outlet is properly grounded for the use of equipment grounds.
 - 1) Use a pigtail socket and a 240-volt bulb. Hold one of the leads on the metal screw, holding the cover plate in place, and the other lead in one or the other of the slots in the outlet.
 - 2) The test lamp will glow when the lead to the outlet is in the slot connected to the fuse or breaker back at the panel if the outlet is grounded.

ACTIVITY:

1. Diagram an outlet and a light switch. (130R-22)
2. Diagram a three-way switch light circuit. (130R-20)
3. Practice doing each of the four different splices
4. Repair a heater or service cord.
5. Make an extension cord.
6. Wire a convenience and light circuit.
7. Have students wire the circuit they diagramed and then test their wiring with an outlet tester.

Special Material and Equipment:

Electrician's pliers, knife, solid single 14 gauge wire, soldering iron, 50-50 resin-core solder, electrician's tape, Screwdriver, pocket knife, cords, extra plugs.
Hand tools suitable for electrical wiring, cable ripper, wire stripper, 14-2 w\g cable, switch box, octagon box, single-pole switch, three-way switch, porcelain lamp holder, duplex receptacle, switch cover, outlet cover, wire nuts, test light, voltage meter.

References:

Cooper, E. L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Erpelding, L. H. (1971). AGRIBUSINESS ELECTRICAL LESSON PLANS. Danville, IL: Interstate Printers & Publishers.

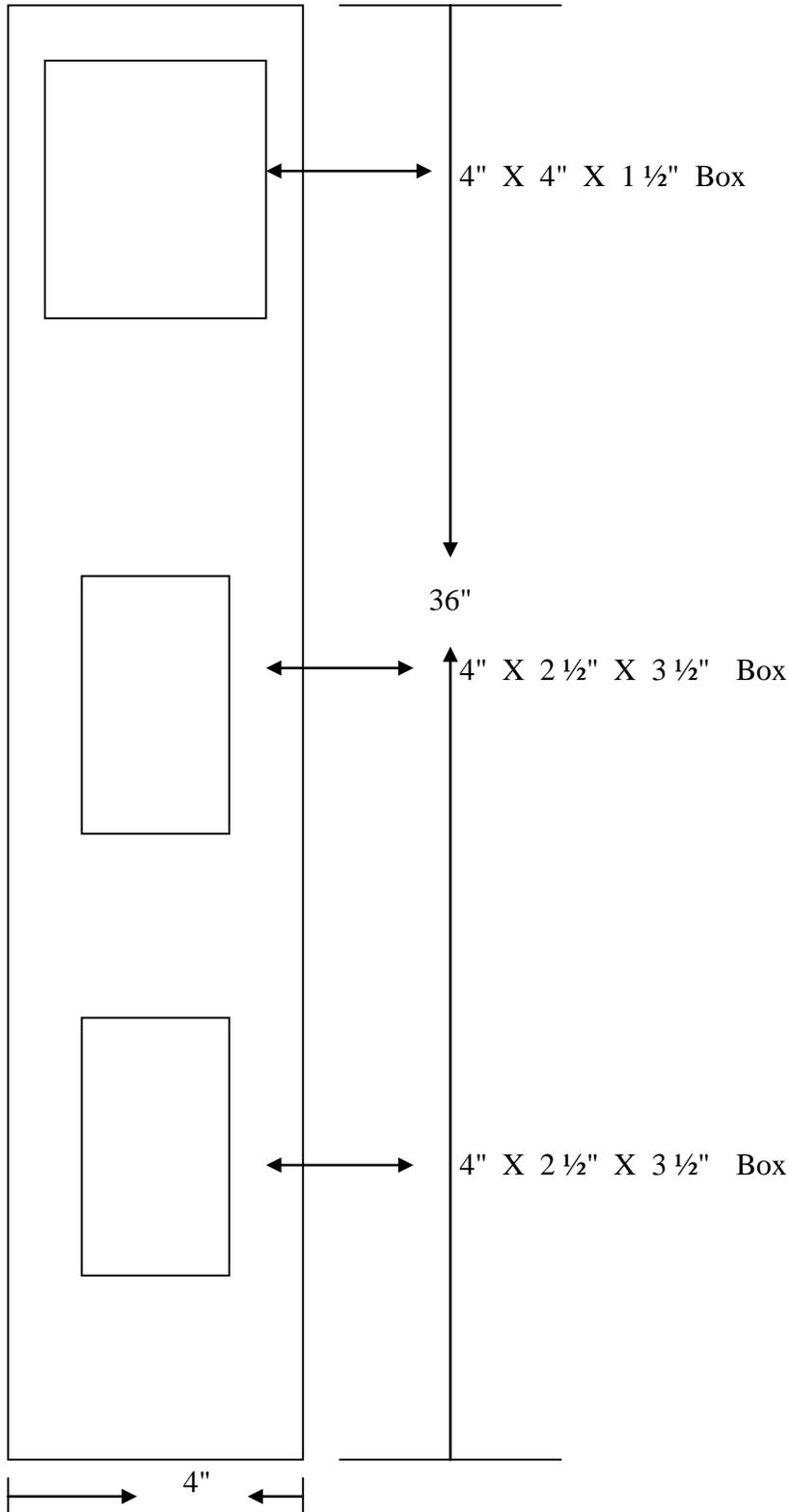
Gustafson, R. J. (1980). FUNDAMENTALS OF ELECTRICITY FOR AGRICULTURE. Westport, CT: AVI Publishing Company.

NATIONAL ELECTRICAL CODE, 1999

Richter, H. P., Schwan W. C. (1999) WIRING SIMPLIFIED, 39th EDITION, Minneapolis, MN: Park Publishing, INC.

McReynolds, Ray (1997) STEP BY STEP GUIDE BOOK ON HOME WIRING, Step-By-Step Book Co. Salt Lake City, Utah 1-800-678-1500

WIRING PROJECT BOARD



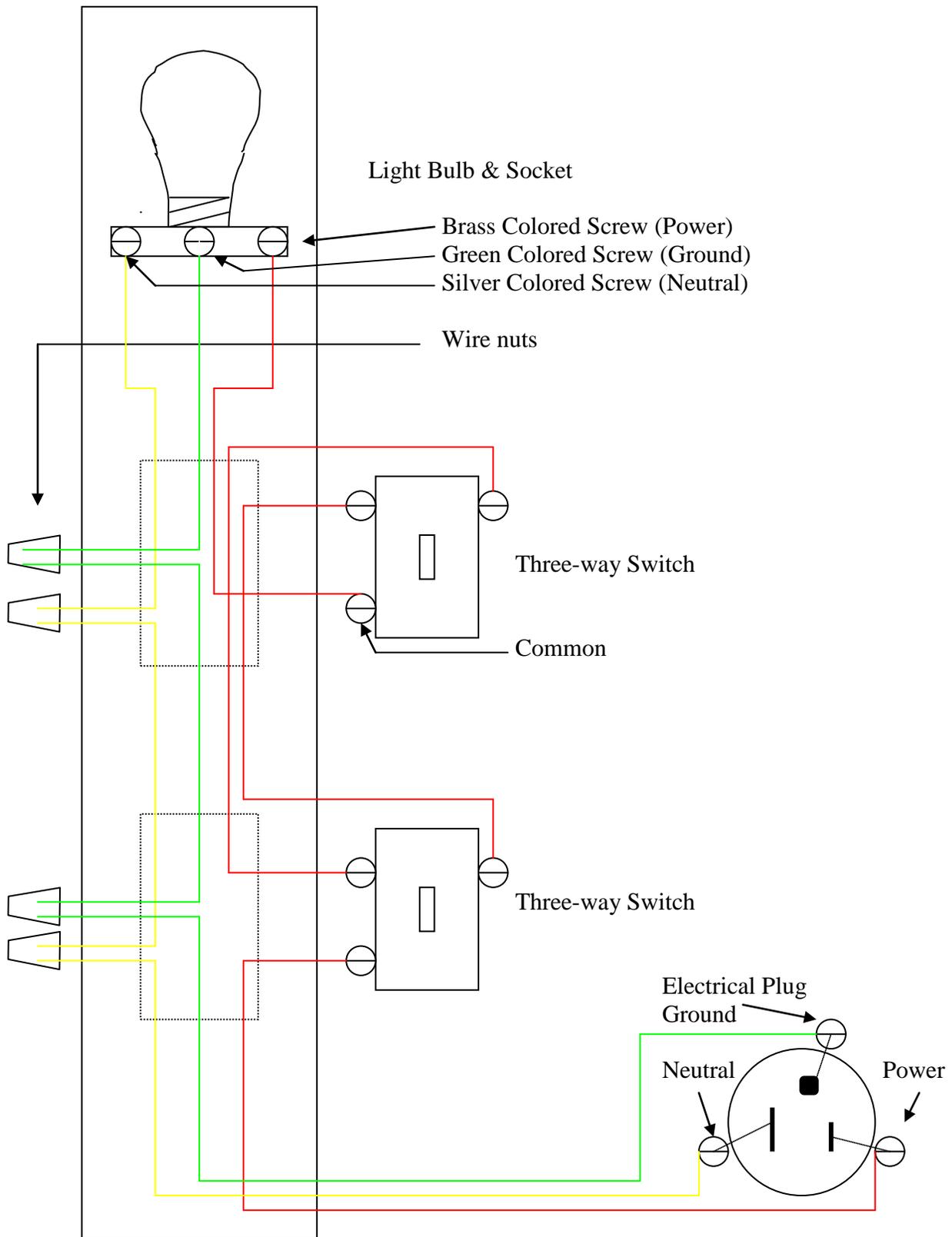
Using 1" X 4" lumber for the board, fasten junction boxes to the board using 1/2" wood screws.

Using romex cable to wire the boxes with any combination of outlets, switches, and a light at the end.

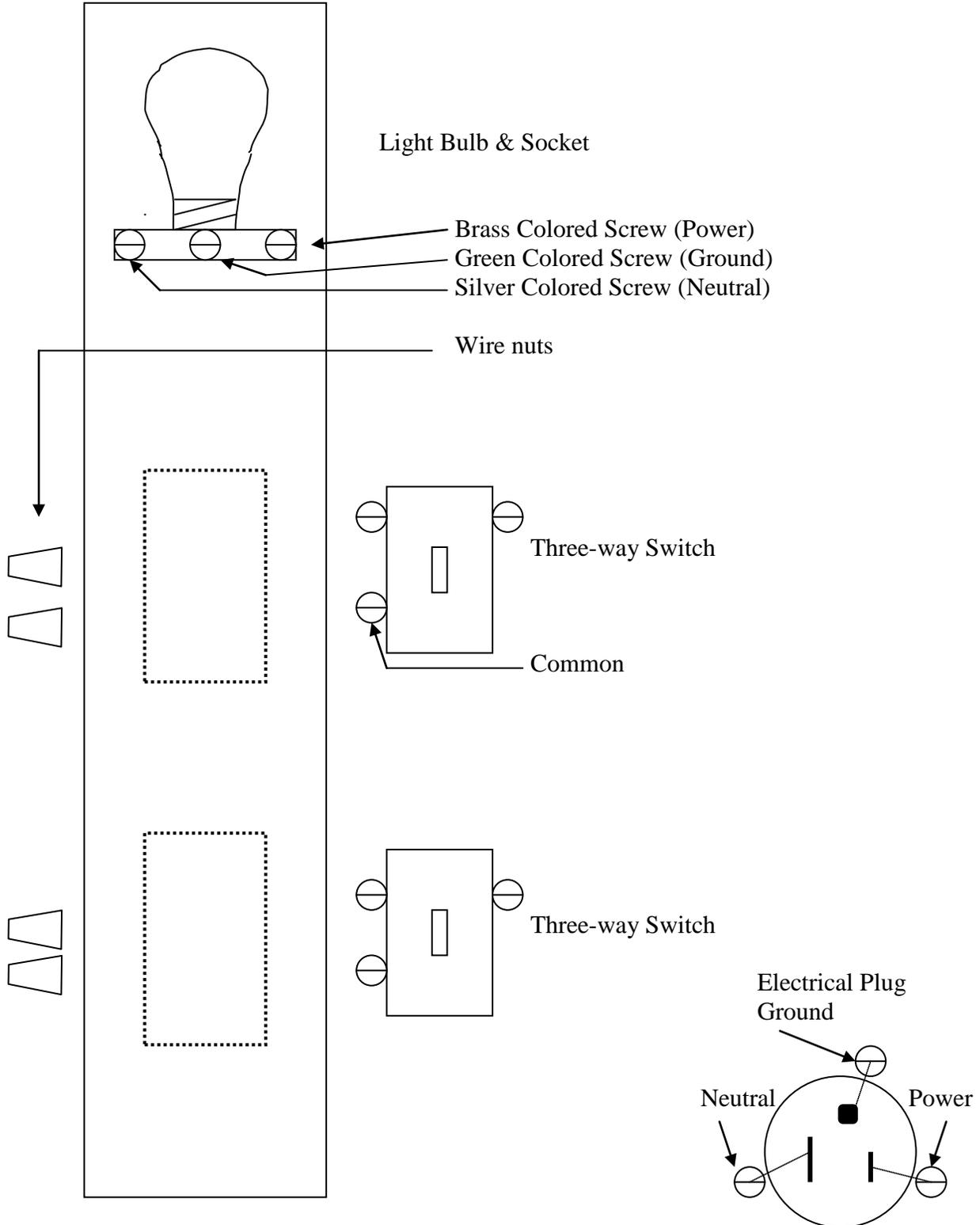
Have students use the drawing on the next page to draw out the wiring before wiring the junction boxes.

Use a grounding screw in all metal boxes

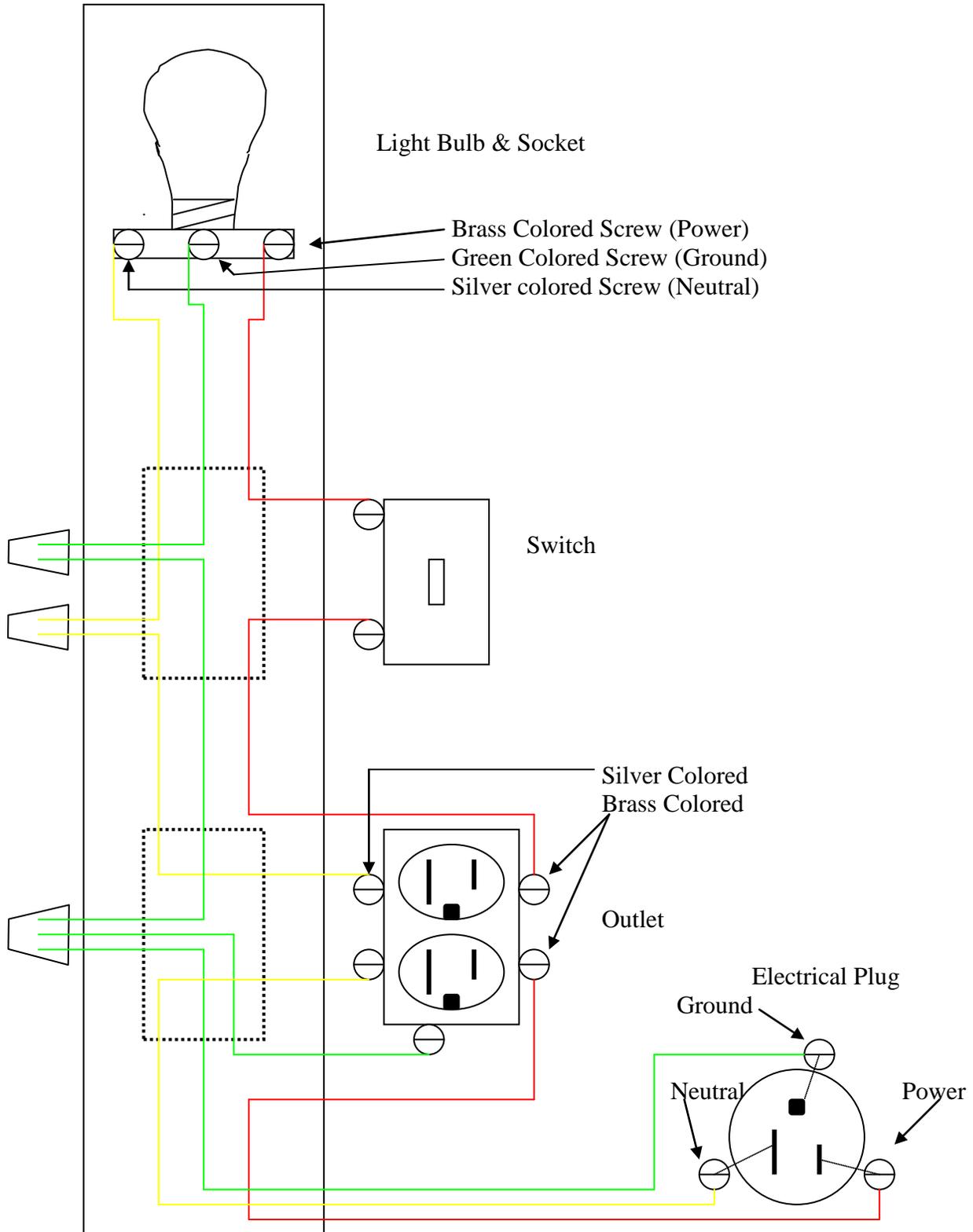
WIRING PROJECT- THREE-WAY SWITCH



WIRING PROJECT- THREE-WAY SWITCH Score _____



WIRING PROJECT – OUTLET & SWITCH

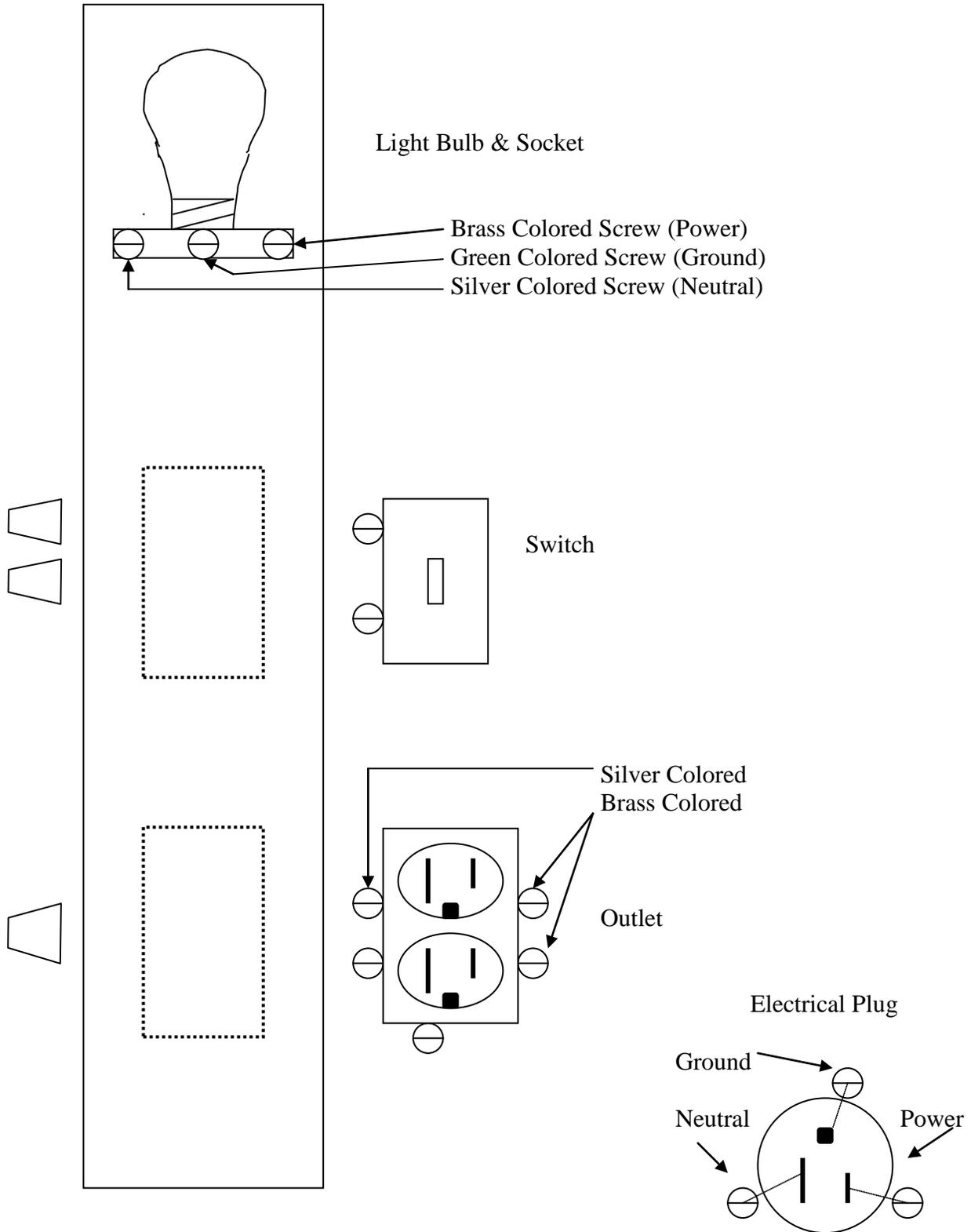


Name _____

Date _____

Score _____

WIRING PROJECT – OUTLET & SWITCH



Name _____

Date _____

Score _____

UNIT EXAM

INTROUCTION TO ELECTRICTY AND ELECTRICAL WIRING PRACTICES

Questions 1 – 20 are true or false questions, circle T for true and F for false.

1. T or F Some form of electricity is present in all matter.
2. T or F Electrons carry a positive electrical charge and orbit around the center of the atom.
3. T or F When free electrons move randomly from atom to atom, their energy is small.
4. T of F The speed of electric current is greater than the speed of light.
5. T or F Fuses or breakers with an amperage larger than the wire's rated current amperage will not protect the circuit from overheating.
6. T or F Stranded wire improves flexibility.
7. T or F Electricity travels on the outer surface of the wires.
8. T or F Aluminum conductors require one wire size larger than copper wire to provide the same load.
9. T or F The Cable marking, 12-2 w/g, indicates that the cable has one black 12 gauge wire and one white 12 gauge wire and is water resistant guaranteed.
10. T or F Electrical cable is generally used for permanent indoor installation.
11. T or F In electrical work, e.m.t. stands for emergency medical treatment.
12. T or F Type THWN wire is only used in dry locations with high temperatures.
13. T or F A wire splice cannot be expected to conduct electricity as well as the unspliced wire.
14. T or F When stripping a wire with a knife, the knife should be held a 90-degree angle to the wire and run around the wire to cut the insulation.
15. T or F When replacing insulation with plastic electrician's tape, it should be wrapped around until the layers equal the thickness of the insulation removed.
16. T or F The neutral wire is attached to an electrical switch in a circuit.
17. T or F The black or red wire is the hot wire in an electrical circuit.
18. T or F A circuit test light can be made from a pigtail light socket.
19. T or F A 220 volt circuit has two 110 volt hot wires.

20. T or F Bulbs of different wattage can be installed in a homemade, pig-tail socket, test light to test circuit voltage.

B. Matching, write in the correct letter

- | | |
|--|--------------------|
| 1. _____ A break in the circuit so that the current cannot flow | a. watt |
| 2. _____ A measure of electron flow | b. fault |
| 3. _____ A measure of electrical power | c. insulator |
| 4. _____ A measure of electrical pressure | d. short |
| 5. _____ A material through which electrons can flow freely | e. ampere |
| 6. _____ A material that provides great resistance to electron flow | f. grounding |
| 7. _____ A measure of resistance | g. U.L. |
| 8. _____ Electrons not readily moved from their orbits | h. end splice |
| 9. _____ A direct connection between a hot wire and a ground connection | i. volt |
| 10. _____ A leakage of current from a hot wire to a ground connection | j. conductor |
| 11. _____ Abbreviation of the name of an organization that tests electrical products for safety | k. ohm |
| 12. _____ Used to join two wires together so the joint is as strong as the unspliced wire | l. planetary |
| 13. _____ Used when one wire must be tapped into another at some point other than at its end | m. open circuit |
| 14. _____ Used to join wires where there will be no strain | n. branch splice |
| 15. _____ Providing an additional connection between a piece of electrical equipment and the earth | o. rat-tail splice |

C. Multiple Choice, circle the correct answer

1. Which symbol in the equation, $A = V/R$ (Ohm's Law), is not defined properly below?
 - a. A equals insulation in amperes.
 - b. V equals potential energy in volts.
 - c. R equals resistance in ohms.
 - d. None of the above.

2. At which level of amperage does a fatal shock usually occur?
 - a. 5 amps
 - b. 10 milli amps
 - c. 15 milli amps
 - d. None of the above.

3. Which copper wire gauge size has the wrong ampere rating?
 - a. No. 14, rated for 15 ampere circuits.
 - b. No. 12, rated for 20 ampere circuits.
 - c. No. 10, rated for 25 ampere circuits.
 - d. None of the above.

4. Which item listed below is not a part of a simple circuit?
 - a. A hot wire and a neutral wire.
 - b. Electrical boxes and outlets.
 - c. Fixtures and switches.
 - d. A voltage transformer.

5. 110V overcurrent protection devices are connected to which wire in a circuit?
 - a. Black
 - b. White
 - c. Green
 - d. Bare

6. To which terminal screw on a 110V duplex outlet is the black wire connected?
 - a. Silver or white
 - b. Gold or yellow
 - c. Green
 - d. None of the above.

7. A simple three-prong outlet tester can test all but which of the following?
- a. Open ground
 - b. Hot and ground wire reversed
 - c. Open neutral
 - d. Circuit voltage
8. Which of the following is the best conductor of electricity?
- a. aluminum
 - b. copper
 - c. silver
 - d. iron
9. Which of the following materials is not a good insulator?
- a. glass
 - b. plastic
 - c. rubber
 - d. oily leather
10. Since one watt is equal to one volt pushing one ampere through a conductor ($W = VA$), how many watts would be produced by 110 volts pushing 10 amperes?
- a. 11W
 - b. 120W
 - c. 1,100W
 - d. 11,000W

ANSWER SHEET

A. True and False

1. t
2. f
3. t
4. f
5. t
6. t
7. t
8. t
9. f
10. t
11. f
12. f
13. f
14. f
15. t
16. f
17. t
18. t
19. t
20. t

B. Matching

1. m
2. e
3. a
4. i
5. j
6. c
7. k
8. l
9. d
10. b
11. g
12. h
13. n
14. o
15. f

C. Multiple Choice

1. a
2. b
3. c
4. d
5. a
6. b
7. d
8. c
9. d
10. c

130S-1

ELECTRICAL MOTORS

AG 130-S

UNIT OBJECTIVE

After completion of this unit, students will be able to identify the different types of electrical motors, understand the different uses, and identify the best electrical motor for a certain job. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Understand terms associated with electric motors.
2. Identify different types of electrical motors.
3. Understand the different characteristics of each type of electrical motor.
4. Identify parts of an electrical motor.
5. Identify requirements of an electrical motor.
6. Identify information found on the nameplate of an electrical motor.
7. Understand the reasons for different type of motor enclosures.
8. Name factors to consider in selecting electric motors.

GENERAL INFORMATION

A. Terms

1. Single phase – Type of electrical service available to most farms; requires one transformer between power supplier and customer
2. Split phase motor – Cheapest electric motor available; used for easy starting loads.
3. Induction-run motor – Motor that runs by induced current and does not have windings in the motor.
4. Repulsion-start motor – Motor that has windings in the rotor and also has brushes and a commutator.
5. Capacitor-start motor – Motor that has a capacitor wired in series with the starting windings.
6. Horsepower (hp) – Unit of mechanical power which is equal to 746 watts of electrical power
7. Short circuit – A circuit where the current flows to a ground with no resistance in the circuit.
8. Three phase motor – Most rugged, reliable, and satisfactory type of motor available; used for fairly difficult starting loads.
9. RPM – Revolutions per minute
10. Automatic motor control – Switch, relay, and/or a contactor capable of responding to a device that senses variations in temperature, humidity, light, and pressure.
11. Relays – Device capable of utilizing a sensing signal to open and close a (switch) circuit.
12. Commutator – Switch for revering the direction of an electrical motor

B. Types of A.C. single-phase, induction-run motors

1. Split phase

- a. Cheapest electric motor available
- b. Available in sizes up to 1/3 hp
- c. Uses single-phase power
- d. Uses 120-volt and/or 240 volt service
- e. Used on easy starting loads
- f. Examples: Grinders, saws, washing machines

2. Repulsion-start

- a. Uses single-phase power
- b. Available in sizes from 1/6 to 10 hp
- c. Uses 120 volt and/or 240 volt service

130S-3

- d. Used on hard to start loads
- e. Examples: Bunk feeders, milking machines, silage blowers

3. Capacitor-start, capacitor-run

- a. Uses single-phase power
- b. Has two capacitors; one for starting and one for running
- c. Available in sizes of 5 to 10 hp
- d. Used on hard-to-start loads
- e. Examples: Pumps, large conveyors, feed mills

4. Repulsion-start, capacitor-run

- a. Uses single phase power
- b. Is a combination, the capacitor helps maintain running efficiency after the motor reaches operating speed
- c. Available in sizes of 1 to 15 hp
- d. Examples: Grain conveyors, deep well pumps, barn cleaners

C. Three Phase Motors

- 1. Uses three phase 220/240 or 440/480
- 2. Low to medium starting current with high starting torque
- 2. Available in 1/2 to 400 hp or greater
- 3. Examples: Irrigation pumps, elevators, conveyors

D. Variable Speed Motors

1. Types of Variable Speed Motors

- a. Adjustable-voltage D.C.
- b. Adjustable-voltage A.C. (Most commonly used on farms today.)
- c. Adjustable-frequency A.C.
- d. Wound-rotor motors

2. Types of Voltage controls

- a. Variable transformer
- b. Series resistors
- c. Solid-state power control

3. Precautions in Operating a Variable Speed Motor

- a. Limit the low speed setting to provide proper bearing lubrication

130S-4

- b. Control unit should provide sufficient voltage to start the motor under a load while at low speed setting.
- c. The lowest speed should still provide enough ventilation to prevent overheating

E. Parts of an Induction Run Motor

1. Ventilated end bell or shield
2. Stator and frame
3. Thermal protection
4. Centrifugal starting switch
5. Sleeve bearing
6. Rotor and fans
7. Resilient mounting

F. Electric Motor Nameplate & Standards

1. Type of current – AC or DC
2. Type of overload protection
3. Horsepower – Horsepower the motor will produce at rated speed
4. RPM – Speed or speeds the motor will operate. Generally there are four speeds the motors are designed to operate, 3,400RPM (2 pole), 1,725RPM (4 pole), 1140 (6-pole), and 825RPM (8-pole)
5. Temperature at which is to be operated
6. Volts – Voltage at which the motor may be operated. Generally, 115/120 or 220/440. More information on the backside of the conduit box cover.
7. Amps – Amount of Amps used at operating load
8. Type of enclosure
9. Motor type – *sp* for split phase, *cs* for capacitor-start etc.
10. Type of frame – Frame size as defined by the National Electric Code
11. Cycle – Indicates frequency at which the motor is to be operated, almost always 60 cycles
12. Serial number – Manufactures Code Number

G. Selecting an Electric Motor

1. Type of electrical power available (Three phase or single phase)
2. Type and size of load
3. Conditions under which a motor must operate (Indoor or outdoor, wet or dry)
4. Types of motor enclosures
 - a. Drip-proof – Water can drip on the motor with out causing any harm
 - b. Splash-proof – Stops water from coming in at a 100* angle

- c. Weather-protected – Designed to minimize the entrance of rain, snow, and dust
 - d. Totally-enclosed – Prevent free exchange of air
 - e. Dust-ignition-proof – Built to exclude ignitable amounts of dust into the motor
 - f. Submersible – May be submersed in water, submersible pumps
5. Type of Frame – A standard size is set up by the government, so one make can be replaced by another. For example, a General Electric motor can be replaced by a Dayton motor by knowing the type of frame.
- a. Bolt pattern for mounting
 - b. Shaft Size
 - 1) Diameter of shaft
 - 2) Length of the shaft
 - 3) Height from the base of the motor

6. Estimate the motor size needed

- a. If a job can continuously be operated by hand, a 1/4 hp electric motor will do the job
 - b. If equipment is driven satisfactory by a gasoline engine, the engine can normally be replaced with an electric motor of about 2/3 to 3/4 as much horsepower as a gasoline engine
- Example: To replace a 2 hp gasoline engine

$$2 \times \frac{2}{3} = \frac{4}{3} = 1 \frac{1}{3}, \text{ Select a } 1 \frac{1}{2} \text{ hp electric motor}$$

H. Power Consumed by Motors

1. Approximate figures for a 2 HP motor are as follows:

- | | |
|------------------------------|------------|
| a. While Starting | 4000 watts |
| b. While Idling | 400 watts |
| c. While Delivering 1/2 HP | 750 watts |
| d. While Delivering 1 HP | 1150 watts |
| e. While Delivering 1 1/2 HP | 1500 watts |
| f. While Delivering 2 HP | 2000 watts |
| g. While Delivering 2 1/2 Hp | 2600 watts |
| h. While Delivering 3 HP | 3300 watts |

* Note, motors operate the most efficiently at rated horse power

I. Reversing Motors

1. Single phase motors

a. Repulsion-Start motors

1) Change the position of the brushes

b. Other single phase motors

1) Reverse the two leads of the starting winding in respect to the two leads from the running winding.

2. Three phase motors

a. Reverse any two of the three leads

J. Causes of motor failure

1. Overheating – Heat is one of the most destructive causes of motor failure.

Overheating is caused by

a. Overloading

b. Low voltage

c. Excessive ambient temperature

d. Poor cooling caused by dirt or lack of ventilation.

2. Moisture

a. Improper selection of motor enclosure

3. Bearing failure

a. Poor lubrication

b. Bearings may fail in unused motors that are not rotated for extended periods

4. Starting Mechanism failure

a. Not kept free of dirt and moisture

5. Belt too tight or too loose

6. Machine locked or jammed

130S-7

Activity:

1. Have students take apart old junk motors and look at the internal parts.
2. Have students look at motors at home or on the farm and report back the different types of motors, enclosures, etc, they found.
3. Have students wire a new cord on an electric motor.

References:

Cooper, E. L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Erpelding, L. H. (1971). AGRIBUSINESS ELECTRICAL LESSON PLANS. Danville, IL: Interstate Printers & Publishers.

Gustafson, R. J. (1980). FUNDAMENTALS OF ELECTRICITY FOR AGRICULTURE. Westport, CT: AVI Publishing Company.

NATIONAL ELECTRICAL CODE, 1999

Richter, H. P., Schwan W. C. (1999) WIRING SIMPLIFIED, 39th EDITION, Minneapolis, MN: Park Publishing, INC.

McReynolds, Ray (1997) STEP BY STEP GUIDE BOOK ON HOME WIRING, Step-By-Step Book Co. Salt Lake City, Utah 1-800-678-1500

SELECTING AND USING ELECTRIC MOTORS, U.S. Department of Agriculture, Farmers Bulletin No. 2257

Special Material and Equipment:

Old electric motors, electrician's pliers, solid single 14 gauge wire, electrician's tape, screwdriver, pocket knife, cords, extra plugs. Hand tools suitable for electrical wiring, cable ripper, wire stripper, 14-2 w\g cable, switch box, octagon box, single-pole switch, voltage meter.

Name _____

Date _____

Score _____

ELECTRICAL MOTORS

Multiple Choice, Select the most correct answer for the following questions.

1. _____ What type of motor enclosure would you use in a damp situation where water drips on to the motor?
 - a. Splash proof
 - b. Drip proof
 - c. Weather proof
 - d. Dust proof

2. _____ What type of motor enclosure would you use in a feed mill operation where dusty conditions are high?
 - a. Splash proof
 - b. Drip proof
 - c. Weather proof
 - d. Dust proof

3. _____ What are considerations for selecting a motor?
 - a. Type of electrical power available (single or three phase)
 - b. Type and size of load.
 - c. Conditions under which the motor must operate
 - d. All the above

4. _____ When does an electrical motor consume the most power?
 - a. while running at rated load
 - b. while starting
 - c. while running above the rated load
 - d. while at idle

5. _____ What does the nameplate data, Type of Frame NOT include?
 - a. Shaft size
 - b. Bolt pattern
 - c. RPM
 - d. Shaft length

Short Answer, answer the following questions with a short answers.

6. Name three causes of electrical motor failure

a. _____

b. _____

c. _____

7. To replace a 5hp-gasoline engine, what size of electrical motor would you need?

8. Name four items found on an electrical motor nameplate.

a. _____

b. _____

c. _____

d. _____

9. What type of an electrical motor would be used on irrigation pump requiring 20hp.

10. How would you reverse the following types of motors?

a. single phase, Repulsion Start

b. single phase, other types

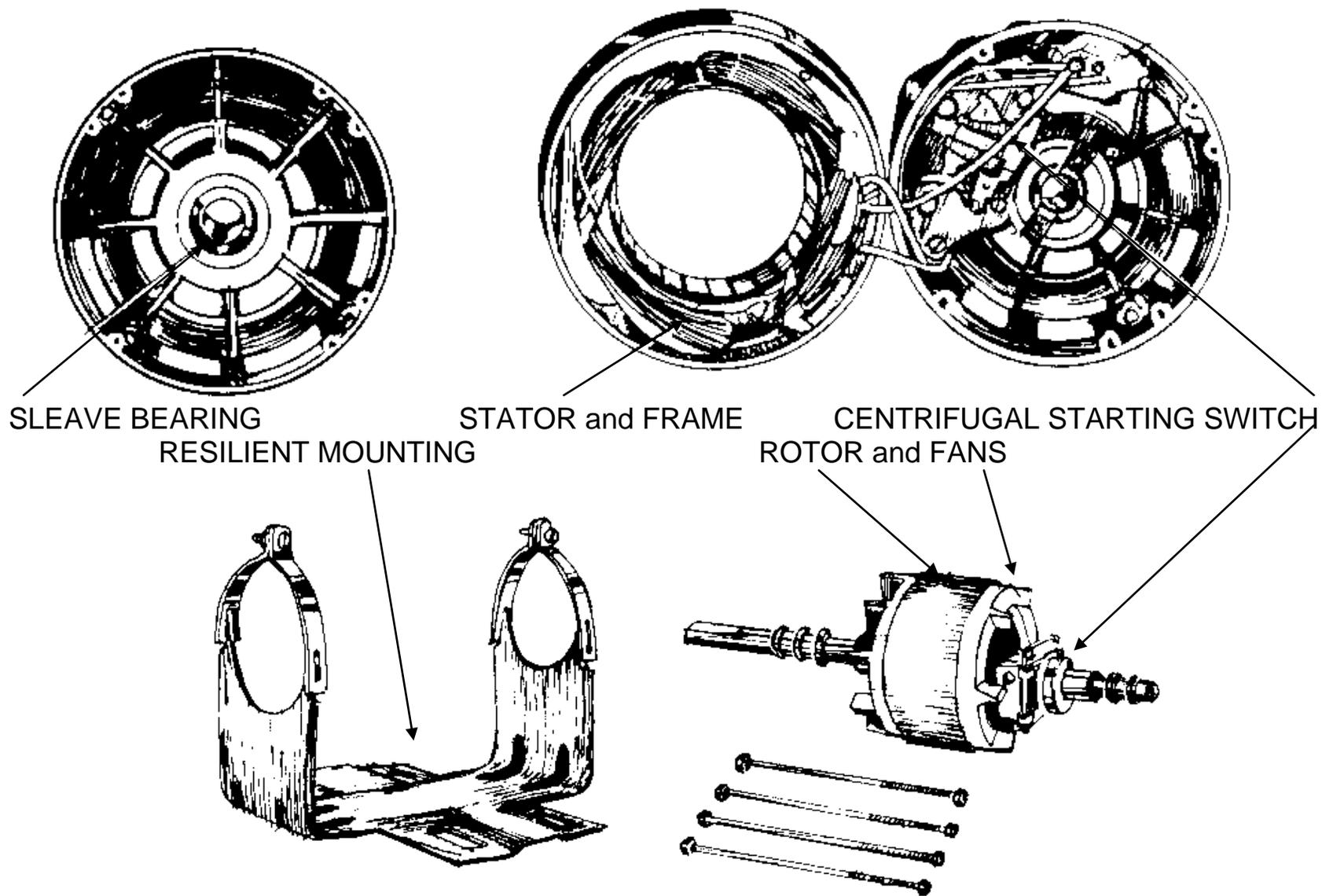
c. three phase motor

Answer Sheet

1. B
2. D
3. D
4. B
5. C
6. Any three of the following; overheating, bearing failure, belt too tight, moisture, locked or jammed
7. $5 \times \frac{2}{3} = \frac{10}{3} = 3 \frac{1}{3} = 3 \frac{1}{3}\text{hp}$ or $3 \frac{1}{2}\text{hp}$ motor
8. Any four of the following; Type of current AC or DC, type of overload protection, horsepower, RPM, operating temperature, volts, amps, type of enclosure, motor type, cycle, type of frame, serial number
9. Three-phase motor with weather proof enclosure
10. a. rotate brushes, b. reverse leads c. reverse any two hot leads

130S-11

PARTS OF INDUCTION-RUN MOTOR



130T-1

SERVICING SMALL ENGINES

AG 130-T

UNIT OBJECTIVE

After completion of this unit, students will understand the basic operation of small engines and power equipment and perform basic maintenance and service procedures on a small engine. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Describe the maintenance of small engines, with respect to air cleaner, lubrication, and fuel.
2. Follow safe operation guidelines when using small engine equipment.
3. Describe the basics of engine operation; starting, stopping, and controls.

ENGINE OPERATION

A. Internal combustion engines can be classified either according to the type of fuel used to power them or by the cycle rotation of the engine. There are currently four different classifications of internal combustion engines that are in use today: Gasoline, two-stroke and four stroke. Diesel, two-stroke and four stroke.

1. Two-stroke engines are commonly used in small hand held power machinery such as chain saws, weed eaters, brush cutters, power augers and older boat motors.
2. Four-stroke engines are commonly used in lawnmowers, roto-tillers, newer boat motors, and other forms of wheel mounted small engine equipment.
3. In the two-stroke engine, lubrication is generally provided by oil mixed with the fuel.
4. Four-stroke engines have a separate reservoir for oil.

B. The Otto cycle (All four steps take place in all engine types).

1. Intake

- a. Diesel engines intake air only into cylinders.
- b. Gasoline engines intake both air and fuel into cylinders.

2. Compression

- a. Diesel engines compress air only.
- b. Gasoline engines compress both air and fuel within the cylinders.

3. Ignition

- a. Diesel engines ignite the air-fuel mixture spontaneously, due to the heat of compression.
- b. Gasoline engines ignite the fuel-air mixture with a spark from the spark plug.

4. Exhaust

- a. Both diesel engines and gasoline engines remove products of combustion (exhaust) by the upward movement of the piston.
- b. Some diesel engines remove exhaust with a blower in addition to removing it with the upward motion of the piston.

C. Basic design concept

1. Two-stroke cycle of operation

- a. A two-stroke engine utilizes one revolution of the crankshaft between each power impulse.
- b. This engine completes all four of the steps of the Otto cycle in only one revolution of the crankshaft.
 - 1) Intake and compression occur primarily during the up stroke (vertical cylinder orientation).
 - 2) Power and exhaust occur primarily during the down stroke (vertical cylinder orientation).
 - 3) Some overlap of the intake and exhaust parts of the cycle occur on a ported two-stroke engine such as a small chain saw or leaf blower.

2. Four-stroke cycle of operation

- a. The four-stroke engine utilizes two revolutions of the crankshaft between power impulses.
- b. This engine provides an individual piston stroke (up or down) to accomplish the complete Otto cycle.
 - 1) Intake - down stroke of piston
 - 2) Compression - up stroke of piston
 - 3) Power - down stroke of piston
 - 4) Exhaust - up stroke of piston
- c. The four-stroke engine must utilize a valve system in order to allow gases to enter the cylinder and escape to the atmosphere.
 - 1) The intake valve provides an opening for incoming gases to enter the cylinder and must be timed correctly for the Otto cycle operation (usually open approximately 215 degrees of crankshaft rotation).
 - 2) The exhaust valve opens to allow burned exhaust gases to escape to the atmosphere (usually open approximately 235 degrees of crankshaft rotation); it is also timed to correctly open in the Otto cycle.

D. Daily pre-start check

- 1. Check for leaking coolant, lubricant, and fuel.

130T-4

2. Check fuel tank level.
 - a. Never let a diesel run out of fuel.
 - b. Drain water and sediment from fuel sediment bowl on gasoline engines.
3. Check cooling fins on air cooled engines for dirt and debris. Check coolant level in radiator of water cooled engines.
 - a. Coolant should be about one inch below the top of radiator cap.
 - b. Make sure the percentage of antifreeze in the water is adequate by measuring the specific gravity with a radiator hydrometer.
4. Check V-belt (fan belt) tension and condition.
5. Check oil level (four-stroke).
 - a. Make sure oil is not grayish (water in oil).
 - b. Add proper engine oil as needed (consult operator's manual). Be careful not to add oil past the "full" mark on the dipstick.
 - c. Some engines can be checked while running; the operator's manual or dipstick will indicate if this is so. Those that are checked while running show level above "full" when not running.
 - d. Some older engines have plugs in place of dipsticks.
6. Check transmission and hydraulic oil levels if applicable.
7. Check and clean air cleaner.
8. Check condition of all air intake hoses and system.
9. Check water level and terminals of battery.
10. Check tire pressure and condition.
11. Check for loose bolts and nuts, tighten as required.
12. Grease all lube points.

D. Starting a gasoline engine

1. Provide adequate ventilation if engine is to be started inside.
2. Check that fuel supply valve is turned on.
3. Place transmission shift lever in neutral or park.
4. Set speed control lever (hand throttle) at 1/4 to 1/3 open.
5. Depress clutch pedal or lever if so equipped.
6. Pull out choke control if engine is cold.
7. Turn ignition switch to on position and crank engine no more than 30 seconds at a time. For pull start engines, pull cord with a sharp, smooth motion. Make sure starter mechanism engages before pulling the rope.

130T-5

8. Push in choke control after engine has started and warmed.
9. Allow engine to run at a moderately fast speed (2,000 rpm). Slowly release the clutch while the transmission still in neutral if machine is equipped with a clutch.
10. Check all gauges and warning lights for normal readings.
11. Allow the engine to warm up for one or two minutes before doing work.

E. Small engine operating safety.

1. Always obtain permission from your teacher before starting an engine.
2. Do not wear open toed shoes while operating power equipment.
3. Do not wear loose fitting clothing that may become entangled in moving parts.
4. Keep safety guards over moving parts in place.
5. Do not touch hot exhaust parts.
6. Operate engines in a well ventilated area.

F. Trouble shooting

1. Trouble shooting is the art of finding the source of engine problems. If an engine fails to start, check for fuel in the tank and oil in crankcase.
2. Check compression by removing the spark plug and covering plug hole with thumb. Crank the engine, air pressure should be felt on the thumb. If there is no compression, add a small amount of oil through the plug hole. This seals the rings. If compression increases, rings are not sealing properly, and valves are. If no change is evident, both valves and rings may be at fault. If the engine has been idle for some time, the "Shot of oil" may be all that is necessary to get the engine to run. To correct low compression it is necessary to overhaul the engine.
3. If engine fails to start but compression is good, check ignition spark as follows:
 - a. Place spark tester in series with the secondary coil wire and spark plug and test for spark. If spark occurs in the spark tester, the coil is functioning properly but there still might be a problem with the spark plug itself. (See page 130T-17)
 - b. If no spark occurs then disconnect from the spark plug and connect to a head bolt.
 - c. If spark still does not occur, check the primary ignition system for problems. If spark does occur, replace the spark plug.

130T-6

4. Engine fails to start but compression and spark are adequate remove air cleaner. Squirt small amount of fuel in carburetor (cool engines only!). If engine starts choke is inoperative or fuel blockage has occurred. To check for fuel blockage answer the following:
 - a. fuel at carburetor?
 - b. filter plugged?
 - c. fuel valve open?
 - d. fuel line plugged?
 - e. dirt or water in fuel system?
 - f. correct fuel/oil mix for two-stroke?
 - g. bolts and screws tight?
 - h. is the carburetor properly adjust according to the manual?

5. An engine with good compression, spark, and fuel delivery should start.

ACTIVITY:

1. Examine a variety of small engine powered equipment and determine whether the equipment is powered by a two-stroke or four-stroke engine.
2. Develop a list of uses for small engines.
3. Go through engine starting procedures with students and have each student start an engine.

SMALL ENGINE MAINTENANCE

A. Importance of preventive maintenance

1. The leading cause of premature failure in agricultural machines is a lack of preventive maintenance.
 - a. Preventive maintenance is most important when the work load is heaviest because the financial losses will be greatest if machinery is down at crucial times.
 - b. While preventive maintenance cannot completely prevent the possibility of machine failure, it reduces it to a minimum.
2. Preventive maintenance saves money on the total cost of operating machinery.
 - a. An engine tune-up can save up to 15% in fuel consumption and increase maximum power by more than 10%.
 - b. Regular maintenance of other components saves money in repairs and prolongs the working life of equipment.
3. Well-maintained equipment is safer to operate.
 - a. Trying to fix broken-down equipment in the field increases the likelihood of accidents and injuries, as, for example, when the operator hurriedly reaches into the moving parts of a machine.
 - b. Poorly functioning brakes or steering can lead to loss of control of the machine and serious accidents and injuries.
 - c. Poorly functioning equipment takes more time and effort to operate and also prolongs the time required to complete the task at hand; these factors contribute to operator fatigue which, in turn, greatly increases the likelihood of accidents and injuries.
4. Systematic preventive maintenance also results in higher resale or trade-in value for tractors and other agricultural equipment.

B. Service schedules

1. Each machine's operator's manual specifies the service schedule exactly tailored to that particular machine.
2. Adhering to the manufacturer's recommended service schedule and also maintaining complete and accurate service records are essential to insure that service is regularly performed at the recommended intervals.

130T-8

3. Service schedules usually have 10-hour, 50-hour, 100-hour, 250-hour, 500-hour, and 1000-hour intervals or service periods.
4. Service records should be kept in a visible, handy place so they can be conveniently referred to when necessary and also constantly remind the machine operators to keep them up to date.

C. Fuel filter maintenance

1. The purpose of fuel filters is to remove water, sediment, air bubbles, and abrasive particles from the fuel before it enters the carburetor (gasoline engine) or the fuel injection pump (diesel engine).
2. Air in the fuel lines of a diesel engine can cause the engine to run rough or not start.
3. Water and dirt are the major enemies of a fuel system, especially in diesel engines.
 - a. Water cause parts to rust, and even a very small amount of rust can damage injectors.
 - b. Water interferes with the proper metering of fuel, thereby causing the engine to run rough.
 - c. Dirt and sediment clog fuel lines and grind away the injection pump's fine fitted parts.
4. Refer to the operator's manual of the equipment for the recommended fuel filter service interval.

D. Importance of cleaning air filters

1. Air cleaners properly serviced remove abrasive materials from the intake air without reducing the huge volume of air required for adequate fuel combustion.
 - a. The air-fuel ratio of a gasoline engine varies greatly. It may be as rich as 2:1 when choking the engine during cold weather starting. A lean mixture (17:1) can give fuel economy but will result in decreased power and an engine that will run hot. A 15:1 air-fuel ratio provides the most economical engine operation (a medium-speed ratio).
 - b. The air-fuel ratio of a diesel engine varies greatly, according to engine speed. At idle speeds the ratio could be as lean as 100:1 or 20:1 for full throttle speeds.

130T-9

2. Dirt or other abrasive materials that enter in the intake air mix with the oil on the cylinder wall forming an abrasive solution, which rapidly wears cylinders, piston rings, and other engine parts.
3. Agricultural equipment usually works in very dusty conditions requiring frequent servicing, at least every 10 hours.

E. Cleaning a dry element air cleaner

1. Inspect the air cleaner and intake system for leaks where dust may enter.
2. Remove the filter element and tap it on the heel of your hand to remove the dust. (Do not tap the element against a hard surface.)
3. Use compressed air to clean the element if tapping does not remove dust. Direct the air up and down the element pleats, blowing from the inside to the outside of the element. If you hold the air nozzle too close you can blow a hole in the paper element.
4. If compressed air is not available, remove the dust with water. Flush the dirt from the inside to the outside of element, then allow the element to dry before reassembling.
5. If oil still remains on the element after following the above steps, soak and gently agitate the element in lukewarm water and filter element cleaner.
6. Rinse the element cleaner off with water (40 psi or less); shake off the excess water, then allow the element to dry.
7. NEVER use fuel oil, gasoline, or solvent to clean a dry element.
8. Check the filter element gasket for damage.
9. If the element or the gasket is damaged, replace it.
10. Clean the inside of the air cleaner body with a clean, damp cloth.
11. Place the element into the cleaner body and carefully reassemble the air cleaner.
12. Record the date and the number of hours on the engine when you serviced the air cleaner.

F. Cleaning an oil foam air cleaner (See page 130T-18)

1. Wash foam element in liquid detergent and water to remove dirt.
2. Wrap foam in cloth and squeeze dry.
3. Saturate foam with engine oil. Squeeze to remove excess oil, until oil no longer drips from the foam. (DO NOT OIL pre-cleaners THAT ARE IMPRINTED "DO NOT OIL.")

G. Importance of changing oil and oil filters. CHECK OIL LEVEL EVERY TIME YOU PUT GAS IN THE TANK!!!!!!!!!!!!!!

1. What is the function of engine oil?

- a. It reduces wear by reducing friction.
- b. It cushions loads by absorbing shock.
- c. It seals the space between the cylinder wall and the piston rings.
- d. It cools engine parts by absorbing heat as it circulates.
- e. It cleans working surfaces.
- f. It provides rust protection by sealing engine parts from the air.
- g. It neutralizes acids which can corrode metal.

2. Why change engine oil?

- a. Oil loses its lubricating qualities as its additives wear out and it picks up dirt and other abrasive material.
- b. Black crankcase oil does not indicate that an oil change is due.
- c. Check the operator's manual for the manufacturer's recommended oil change schedule to insure that the oil is changed before the additives wear out.

H. Changing the oil and oil filter - After each 25 hours of engine use, the crankcase oil should be drained while the engine is warm. Hot oil flows easily and carries the contaminants with it.

1. Start the engine, and let it run until the normal operating temperature is obtained.
2. Turn off the engine and remove the drain plug from the oil pan.
3. Clean off metal particles from the oil drain plug (some are magnetized).
4. Drain the oil for at least five minutes.
5. Before removing the oil filter, clean dirt off the filter and surrounding area.
6. If the filter is self-contained, remove it with an oil filter wrench. If the filter has a reusable bowl, loosen filter bowl and remove the filter cartridge.
7. Throw away the used filter and clean the reusable bowl and base with solvent.
8. Install a new oil filter or reassemble the old filter with a new cartridge.
9. Replace the drain plug in the oil pan.
10. Fill the crankcase with the manufacturer's recommended type of new oil.
11. Start the engine, and operate it for a few minutes at low RPM.
12. Watch the oil pressure gauge or light immediately after starting to verify oil pressure, and check for leaks around drain plug and filter.
13. Turn off the engine and allow a few minutes for the oil to drain back into the oil pan, then check the oil level on the dipstick.
14. Wipe oil off the tools dispose of empty oil cans, and use sawdust to absorb any oil spilled on the floor. Recycle the used oil.
15. Record the date of service and the number of hours on the engine.

ACTIVITY:

1. Clean the air filter on available engines.
2. Change the oil and oil filter on available engines.
3. Test the spark in an engine with a spark tester.
4. Provide students with equipment and manuals. Students can review manuals, start and operate equipment, and make a presentation to the class on the appropriate pre-operation check, starting, operation and safety.
5. Practice trouble shooting disabled engines.

References:

Burke, Stanley R., & Wakeman, T. J. (1990). MODERN AGRICULTURAL MECHANICS (2nd ed.). Danville, IL:Interstate Publishers.

Cooper, E. L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Jacobs, C. D., & Harrell, W. R. (1983). AGRICULTURAL POWER AND MACHINERY. New York: McGraw-Hill.

Briggs & Stratton REPAIR MANUAL FOR SINGLE CYLINDER 4-CYCLE ENGINES

Special material and equipment:

Lawnmowers, weed eaters, chain saws and other gasoline or electric powered equipment, including sample engines of both the two-cycle and four-cycle type. Spark tester, air filters, spark plug wrench.

Name _____

Date _____

Score _____

SMALL ENGINE MAINTENANCE, EXAM

Multiple Choice, Choose the most correct answer for the following questions.

1. _____ Which of the following items do NOT need to be checked before starting a small engine?
 - a. oil
 - b. gasoline
 - c. air cleaner
 - d. spark plug

2. _____ Which engine runs at a higher temperature?
 - a. A two cycle engine
 - b. A four cycle engine

3. _____ How many revolutions does it take to complete a full cycle in a two stroke engine?
 - a. 1 revolution
 - b. 2 revolutions
 - c. 3 revolutions
 - d. 4 revolutions

4. _____ How many revolutions does it take to complete a full cycle in a four stroke engine?
 - a. 1 revolution
 - b. 2 revolutions
 - c. 3 revolutions
 - d. 4 revolutions

5. _____ Having grayish oil in the crankcase indicates?
 - a. Water in the gasoline
 - b. Water in the crankcase
 - c. Old oil
 - d. Gasoline in the crankcase

- 6._____ Which of the following safety procedures can be ignored?
- a. Do not wear open toed shoes while operating power equipment.
 - b. Keep safety guards over moving parts in place.
 - c. Operate engines in a well ventilated area.
 - d. None of the above.
- 7._____ Preventive maintenance is the most important when the _____.
- a. work load is heaviest
 - b. equipment is not being used
 - c. before equipment goes into storage
 - d. work load is the lightest
- 8._____ Regular engine services should be done _____.
- a. when ever the engine looks dirty
 - b. after every tenth time being used
 - c. consult the owners manual
 - d. one a year
- 9._____ The purpose of an air cleaner is to _____.
- a. keep water from getting into the engine
 - b. filter gasoline
 - c. remove abrasive materials form the air
 - d. slow the engine down
- 10._____ Which of the following is NOT a function of engine oil.
- a. reduces wear by reducing friction
 - b. cools engine parts by absorbing heat
 - c. seals the space between the cylinder wall and the piston rings
 - d. used a solvent

Fill in the blanks and short answer

11. Name the four strokes in a four cycle engine.

_____, _____, _____, _____

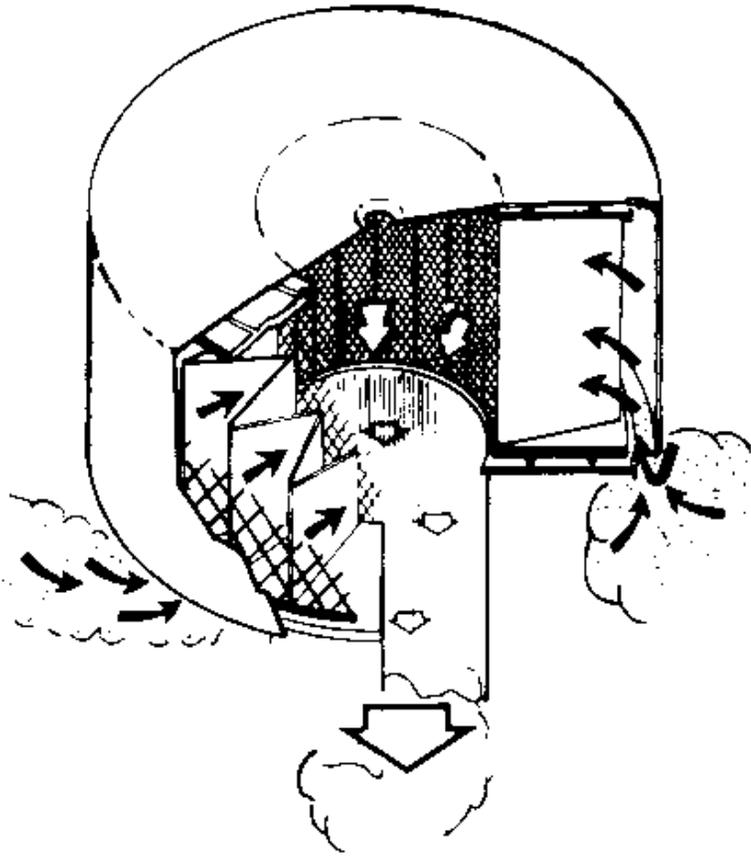
12. How often do you check the oil in a small gas engine?

Answer Sheet

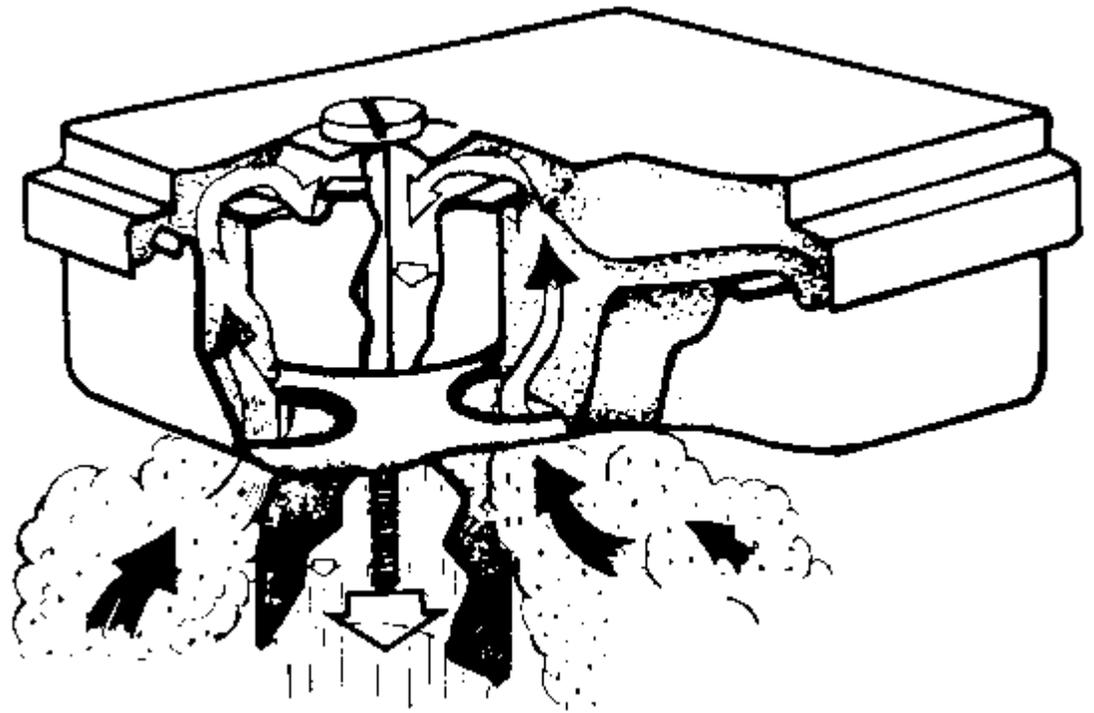
1. D
2. A
3. A
4. B
5. B
6. D
7. A
8. C
9. C
10. D
11. Intake, Compression, Power, Exhaust
12. Every time you put gas in the tank.

130T-15

TYPES OF AIR FILTERS



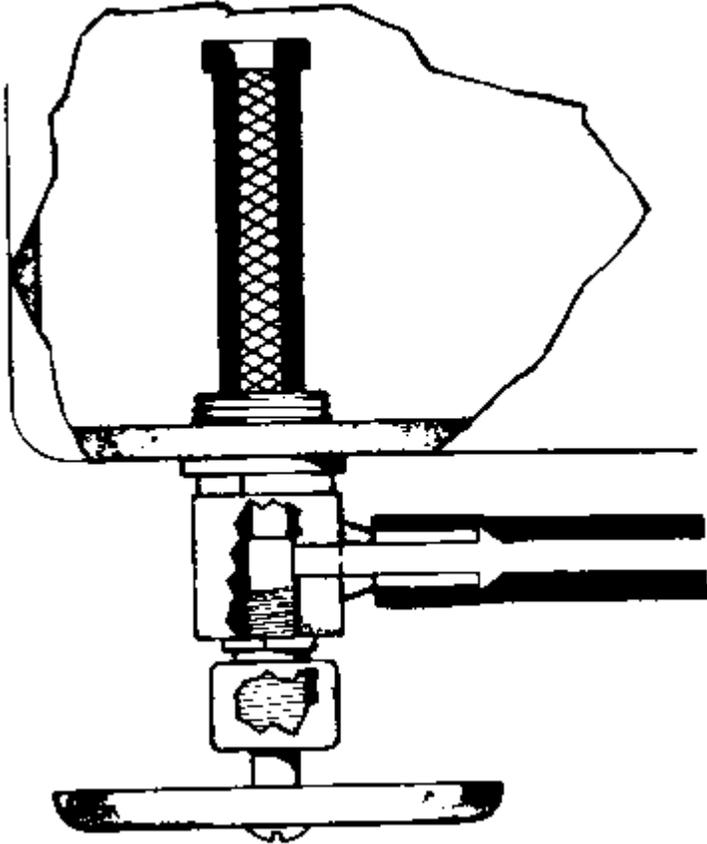
DRY-FILTER



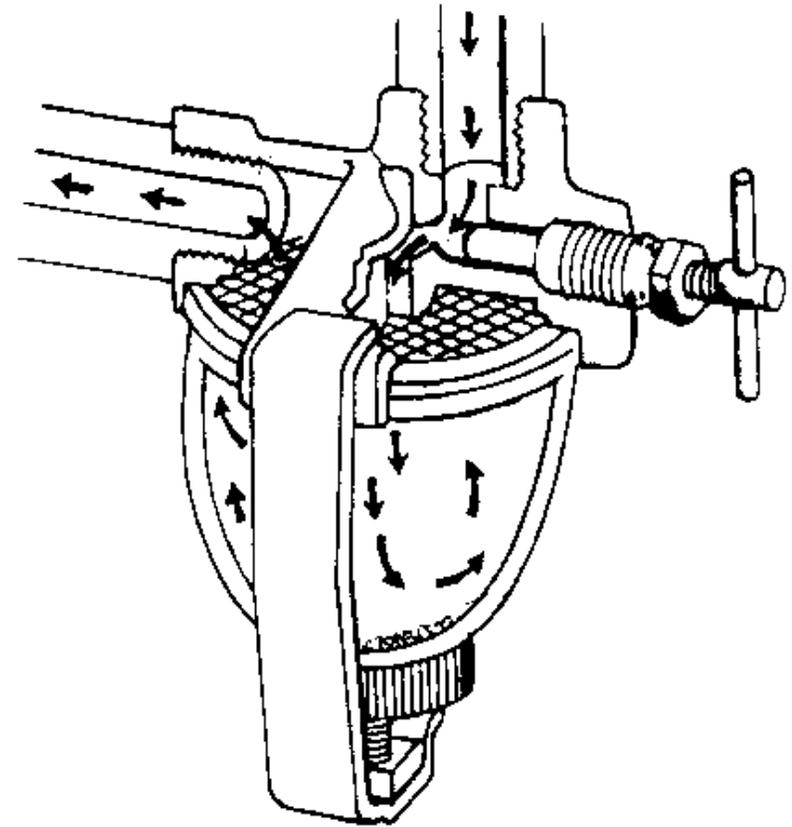
OILED-FILTER

130T-16

TYPES OF FUEL FILTERS



SCREEN IN FUEL TANK

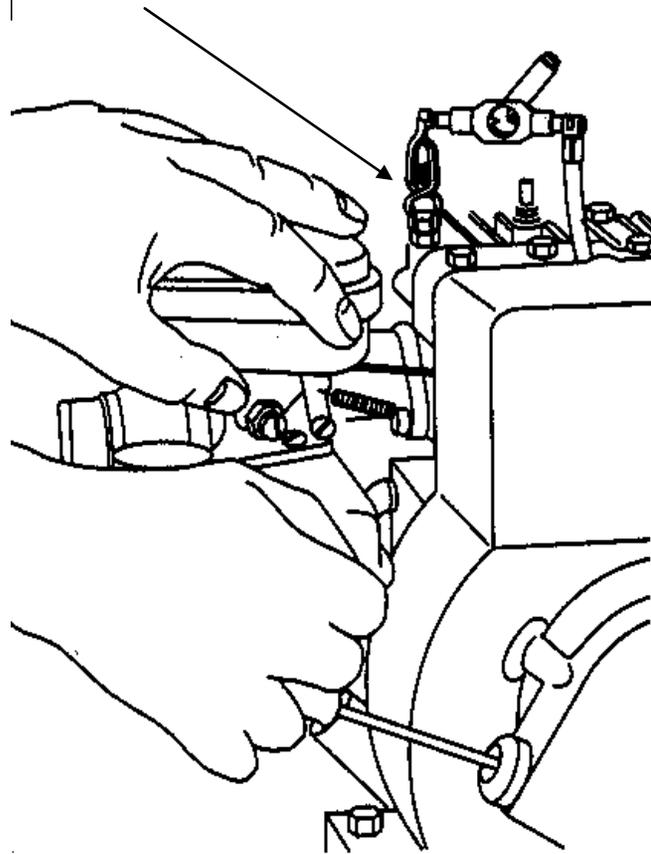


SEDIMENT BOWL

130T-17

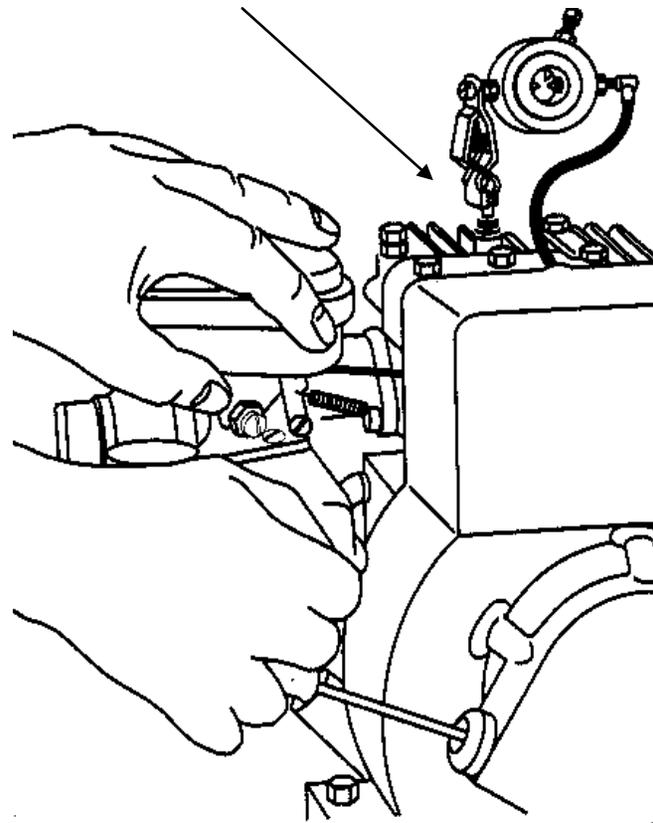
SPARK TESTING

TESTING IGNITION SYSTEM



ATTACH TESTER TO HEAD BOLT

TESTING SPARK PLUG



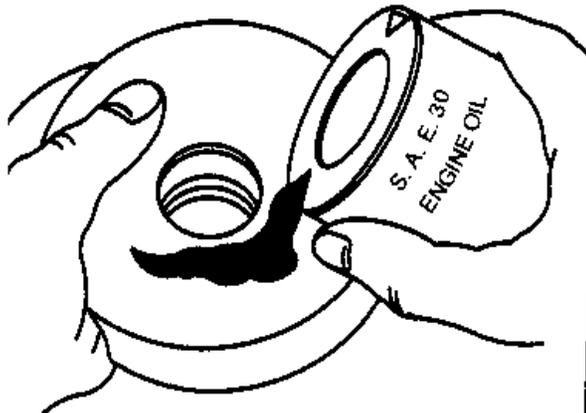
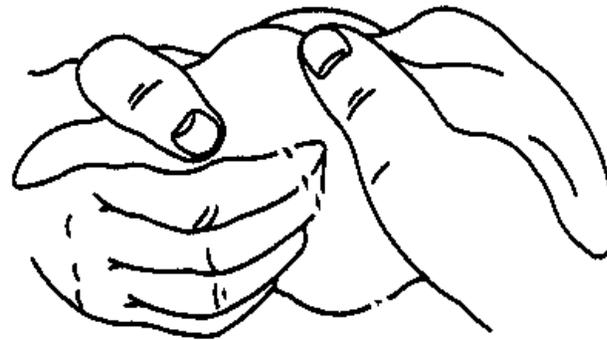
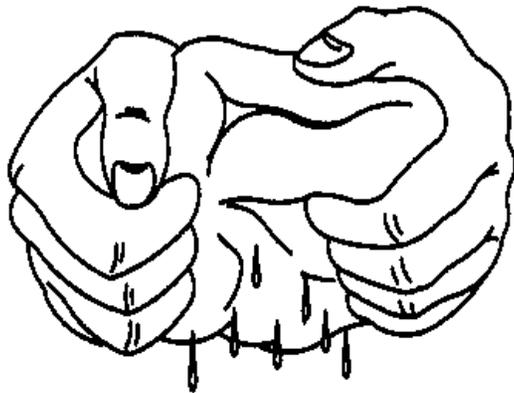
ATTACH TESTER TO SPARK PLUG

130T-18

CLEANING AN OIL FOAM AIR CLEANER

CLEAN WITH DETERGENT AND WATER

WRAP IN CLOTH AND SQUEEZE DRY



SATURATE WITH ENGINE OIL



SQUEEZE UNTIL NO MORE OIL COMES OUT

130U-1

SURVEYING

AG 130-U

UNIT OBJECTIVE

After completion of this unit, students will be able to list the uses of surveying, perform land measurements, and determine the difference in elevation between two or more points. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. List the uses of surveying.
2. Perform land measurements, including pacing and taping of linear distance.
3. Set up and level an instrument and read a rod, ruler, or tape.
4. Determine the difference in elevation between two or more points.
5. Be able to demonstrate proper use of a hand level or clinometer.

SURVEYING IN AGRICULTURE

A. Definition of Surveying

1. Surveying is the art of making relatively large precise measurements with a maximum of accuracy and with a minimum of time and labor.
2. Surveys result in the measurement of one or more of four types of dimensions. These are:
 - a. Horizontal Lengths
 - 1) An example is the measurement of the length of one side of a barn.
 - b. Vertical Lengths
 - 1) An example is the measurement of the height of a barn.
 - c. Horizontal Angles
 - 1) An example is laying out the line of a new fence that will be exactly at a right angle (90 degrees) to an existing fence.
 - d. Vertical Angles
 - 1) An example is the slope of a hillside.

B. Purposes of Surveying

1. It provides field information needed for making maps, charts, and drawings that give exact positions and relative elevations of land, structures, and features.
2. It provides a means to lay out the position, determine the elevation, and check the final construction of land improvements.

C. Uses of Surveying

1. Determine the area of a tract of land.
2. Determine an exact description of the boundaries of a tract of land in terms of engineering measurements of distance and angles.
3. Determine the exact or relative elevation of a series of points in a tract of land.

130U-3

4. Locate exact land or structural boundaries.
5. Lay out exact land or structural boundaries.

D. Uses of Surveying in Agriculture

1. Determining the length of the boundary of a tract of land or the length of a side of a structure.
2. Determining the height of a tree, structure, or hill.
3. Determining the area of a plot of land in acres or the size of a building in square feet.
4. Determining legally specific land boundaries.
5. Determining slopes of land for design of irrigation systems.
6. Determining slopes of land for design of terracing systems.
7. Determining slopes of land for installation of a drain line or a ditch.
8. Determining exact or relative elevation of land to locate ditch pads or other agricultural structures.
9. Locating exact location and orientation of the boundaries of land or the sides of structures.
10. Laying out the exact angles of sides of structures or land boundaries.

SURVEYING EQUIPMENT

A. Steel Tape

1. 100 foot long steel tape (sometimes called a "chain") is most commonly used to measure horizontal distances.
 - a. Has an accuracy of 0.05 feet when used properly
2. Metallic cloth tapes or cloth tapes are also used however, they are generally not as durable or as accurate as steel tapes.
3. Tapes are graduated (marked) in feet and 10ths and 100ths of a foot along their length.
4. Care of the Steel Tape
 - a. Prevent the formation of loops in the tape. If tension (pull) is applied to a looped tape, it can break or permanently kink.
 - b. Loops can be prevented by always keeping a bit of pull on the tape such that no slack develops.
 - c. For measurements of less than the full tape (100 feet), keep the tape on the reel.

- d. When using the full length of the tape off the reel, move it by dragging from one end only.
- e. When a tape is wet, clean and oil it as soon as possible.

5. Use of the Steel Tape

a. Measuring the distance between two points (Point A to Point B)

- 1) Points A and B should be identified with a range pole or other such fixed marker (benchmark, corner of a building, etc.).
- 2) The head tapeman unreels the tape by walking toward point B while the rear tapeman holds the 100 foot end of the tape as near as possible over point A.
- 3) If the head tapeman reaches the end of the tape, the tape should be removed from the reel and a handle or thong attached to the end of the tape.
- 4) If the head tapeman reaches the end point of the tape before reaching point B, the head tapeman should stop and be "lined in."
- 5) The "lining in" process is directed by the rear tapeman to assure measurement along the line to be measured.
- 6) Using hand or verbal signals, the rear tapeman directs the head tapeman to near alignment with point B (which is still in the distance). At this time, the rear tapeman calls out "tape." The head tapeman then stoops, kneels to the left side of the tape and is more accurately "lined in" by the rear tapeman.
- 7) When the tape is on line, the rear tapeman kneels across the tape so that he can sight directly across it (at the "100 foot" reading) to point A.
- 8) The head tapeman should apply tension to the tape (usually 10 or 20 pounds of pull when using a spring gage). When the rear tapeman is centered over Point A (or a chain pin from a previous 100 foot measurement), he will call out "mark" or "right here" at which time the head tapeman will set a pin at the "0" mark of the tape.
- 9) When the head tapeman reaches point B before the end of the 100 foot tape, he stops and the rear tapeman comes up to the last pin that was set before Point B. The tapemen adjust the tape so that an even foot mark is opposite the rear tapeman's pin.

130U-5

- 10) The tape is adjusted such that Point B is within the 0 to 1 foot section of the tape and an exact foot mark is held over the last pin before pin B. The head tapeman pulls tension on the tape and reads the tape to 10ths or 100ths as desired.
- 11) The number read by the head tapeman is subtracted from the foot reading being held by the rear tapeman. If the rear tapeman is aligning the 28 foot line over the last pin and the head tapeman reads 0.44 feet, then a subtraction gives the last distance as $28.00 - 0.44 = 27.56$ feet.

B. Chaining Pins

1. These are steel wire pins about 12 inches long, sharpened on one end and looped at the other end.
2. They are used to mark off exact measurement points along a measured line.

C. Range Poles

1. They are normally about 8 foot long and painted alternately red and white for visibility.
2. Range poles are used to mark the two end points of a line to be measured.

D. Plumb Bob

1. This is a conical piece of metal hung from a string.
2. It is used to assist in measuring true horizontal distance on uneven terrain. This is done by hanging the plumb bob string over the tape (after the tape has been stretched to be level horizontally) and allowing the plumb bob tip to touch the ground to mark the point of measurement or reference.

E. Odometer

1. This is a wheel-like device (normally the diameter of a child's bicycle wheel) with a push handle and a revolution counter which is used to measure horizontal distance.
2. On smooth, horizontal surfaces, this device can measure horizontal distances to within 1%.

130U-6

- a. It is not normally recommended for use for accurate measurement on rough ground or across heavy vegetation.
3. The odometer measures distance by counting the number of revolutions of a wheel of known circumference.
 - a. The horizontal distance measured in feet is equal to 3.1417 times the number of revolutions of the wheel when traversing the line to be measured multiplied by the diameter of the wheel in feet.

4. Using the Odometer to Measure Distances

- a. Set the odometer at the starting point of the line to be measured in such a way that the counter is just beyond the point where it makes the first count.
- b. Set the odometer back to a zero count reading. If the counter cannot be zeroed, record the reading on the counter.
- c. Begin to roll the odometer along the line to be measured at a normal walking pace.
- d. Stop at the end of the line to be measured and record the counter reading.
- e. If started from a counter reading of zero, the final reading will be the net count number and will be used to compute the measured distance. Otherwise, subtract the final reading from the initial counter reading and this number will be the net counter number to compute the measured distance. If the odometer has a conversion scale, use this to convert the net count number to the distance measured. Otherwise, multiply the net count number times 3.1417 times the diameter of the odometer wheel in feet to obtain the distance measured in feet.

F. Tripod Level

1. This is a high-powered telescopic sight with a sensitive spirit level attached to it; it is adjusted so that when the bubble is centered, the line of sight is level.
2. Uses of a Tripod Level
 - a. Differential leveling
 - b. Profile leveling

3. Components of a Tripod Level

- a. Telescope
- b. Three or four leveling screws
- c. Leveling plate and head for fastening the level firmly to the tripod
- d. Tripod

4. Setup of the Tripod Level

- a. Spread the legs of the tripod three to four feet apart and push them individually and firmly into the ground.
- b. Adjust the tripod such that the leveling head (head plate) is approximately level and the telescope is near eye height. Tighten the thumb nuts on the legs to provide rigidity.
- c. Mount the level to the headplate by screwing it down.
- d. Loosen the telescope clamp and swing the telescope barrel directly over two of the leveling screws.
- e. Adjust these leveling screws by tightening one and loosening another simultaneously in order to center the bubble in the bubble tube.
 - 1) This is best accomplished by moving the thumbs together to move the bubble one way and by moving the thumbs away from one another to move the bubble the other way. The bubble will follow the direction of movement of the left thumb.
- f. Turn the telescope over the other pair of leveling screws and repeat the process in order to level the bubble.
- g. Since the process of leveling over one set of leveling screws will affect the level over other screws, the process must be repeated several times over each combination of leveling screws. When level, the bubble will stay level or nearly level throughout a complete 360° rotation of the telescope.
- h. Look through the telescope and focus the cross hairs by adjusting the eye piece with a rotary sliding motion.
- i. Focus on the level rod by turning the objective focus knob.
- j. Check the bubble tube immediately before and after each rod reading. Make any necessary adjustment before the reading is considered correct.
- k. Stand in one position as much as possible when making readings. Stand between the legs of the tripod rather than straddling them; avoid kicking or bumping into the tripod legs.

G. Leveling Rod

1. This is a wooden rod graduated upward from zero at the bottom. It is the tool used to measure distance from the reference plane (at the bottom of the level rod) to the line-of-sight through the level.
 - a. The rod is graduated to feet, 10ths of a foot, and 100ths of a foot.
 - b. The level rod may or may not have a target for use in making readings.
2. A self-reading rod is commonly used and does not have a target. The readings can be taken directly from the person looking through the level telescope.
3. Reading the Level Rod (See page 130U-33)
 - a. Whole feet are delineated by the longest pointed markings on the rod that point at large red numbers.
 - b. The 10ths and 100ths are indicated by smaller divisions between the foot markings.
 - c. Each 10th of a foot division is delineated by a shorter pointed marking as well as by a black number. The exact reading is read at the flat edge of the sharp point.
 - d. Each 100th of a foot division is delineated by alternating black and white markings between the 10th markings. The 100th values are read at the edge of the black or white line, i.e., each marking is 1/100th of a foot wide.
4. Using the Level Rod with the Level
 - a. The person handling the level rod is known as the rodman, whereas the person using the level is the instrument man.
 - b. The rodman must hold the rod in an exact vertical position or the rod will give an incorrect distance from line-of-sight to the point being measured.
 - c. The rod should be held lightly, with the fingers on the edge of the rod. Holding the elbows firmly against the ribs will help to stabilize the rod.

H. Hand Level or Clinometer

1. This is a hand-held device used to make less accurate surveying measurements and estimates.
2. Its components are:
 - a. A sighting tube with a horizontal cross hair to mark the line-of-sight
 - b. A bubble tube
 - c. A small mirror to show a reflection of the bubble through the eyepiece
 - d. Note: When the reflection of the bubble is centered on the horizontal cross hair, the line of sight is horizontal.
3. Uses of a Hand Level or Clinometer
 - a. Used with a level rod to measure slopes
 - b. Used with a board that is marked for locating contour lines
4. Use of a Hand Level with a Level Rod to Measure Slopes
 - a. The level person stands halfway down the slope to be measured.
 - b. The rodman stands approximately 50 feet upslope from the level person with the level rod in the appropriate position.
 - c. The level person sights through the hand level, achieves a horizontal line-of-sight on the level rod and records the reading on the level rod (see procedures in paragraph G-3 above).
 - d. With the level person remaining in the same location, the rodman moves exactly 100 feet down the slope and sets the level rod.
 - e. The level person turns around and repeats step c. above.
 - f. The slope (in percent) is equal to the numerical difference in the two readings. For example:
 - 1) The upslope reading on the level rod is 3.7 feet.
 - 2) The downslope reading on the level rod is 9.9 feet.
 - 3) The distance between the measured points is 100 feet.
 - 4) The slope is $9.9 - 3.7 = 6.2\%$.
5. Use of the Hand Level to Locate Contour Lines
 - a. A contour line is a line of equal elevation (height) on the earth's surface. More commonly, a contour line is thought of as a line of equal elevation around a hillside. Cattle trails that appear to

go horizontally around a hill can be thought of as crude representations of contour lines.

- b. Locating contour lines can be useful in laying out terraces, guides for tillage operations in contour farming, or laying out the centerline for a roadway around a hillside.
- c. Procedure:

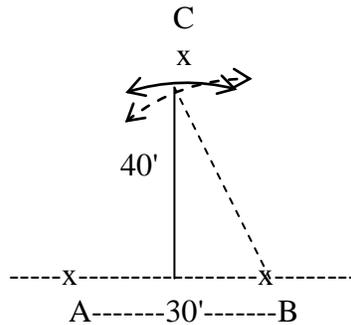
- 1) Initially, the level person determines his or her eye height by sighting on a mark on the level rod, a mark on a board, or a feature or mark on the rodman.
- 2) The initial point on the contour line is selected and the level person stands at this location.
- 3) The rodman moves 50 to 100 feet along the approximate contour line.
- 4) The rodman is directed up or down the slope by the level person sighting through the hand level at the chosen mark (on the level rod, board, or rodman).
- 5) When the cross hairs are aligned with the mark and the bubble, the level person is on the contour line and should drive a stake at this location.
- 6) The rodman should remain by the stake just driven and the level person should move ahead on the approximate contour line to approximately 50 to 100 feet beyond the rodman.
- 7) The level person then sights back to the rodman and moves himself up or down the slope until the cross hairs again line up with the chosen mark on the rodman. At this point, the level person is on the contour line and should drive in a stake.
- 8) The rodman then leapfrogs past the level person as before and the procedure is repeated until the entire contour line has been located.

LAND AREA MEASUREMENTS

A. Pace

1. A pace is the distance (in feet) from the heel of one foot to the point where the heel of the other foot hits the ground.
2. Distances can be measured by pacing when no greater than 2% accuracy (2 feet in 100 feet) is required.

3. Measure a line (5' or 50') from the other end of the base line (Point B) to where it intersects with the scribed arc from step 2 above. When the distance BC is 50', then a right angle has been formed.
4. Set a pin or stake where the two arcs intersect (Point C).



C. Using the tape to determine field area (in square feet and acres).

1. Measure the sides of the field (in feet) using one of the techniques described previously.
2. Calculate the area of the field in square feet.
3. Divide the area of the field in square feet by 43,560 square feet to determine the area of the field in acres.
 - a. There are 43,560 square feet in one acre. For example: if a field is measured and determined to have 85,000 square feet, the number of acres in the field can be determined by the following computation:

$$\text{Area in acres} = 85,000/43,560 = 1.95 \text{ acres.}$$

4. Use the following formulas to determine the area of common geometric-shaped fields:
 - a. Square or rectangular fields:

- 1) $\text{Area} = (\text{width})(\text{length})$

Where,

width = width of the field in feet

length = length of the field in feet

b. Triangular fields:

1) $\text{Area} = (1/2)(b)(h)$

Where,

b = length of the base of the triangular field in feet

h = perpendicular height to the base of the triangular field in feet

c. Circular fields:

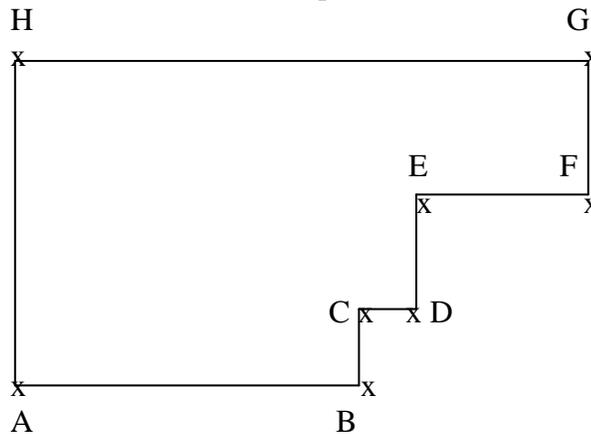
1) $\text{Area} = (3.1417) * R^2$

Where,

R = radius of the field in feet

d. Irregularly-shaped fields:

- 1) Make an accurate (scale) drawing of the field.
- 2) Break the field down into recognizable shapes and compute the area of each part.
- 3) Add all of the areas of the parts of the field to get the total area of the whole field. For example: you have measured off the field pictured below. Compute the area of the field in square feet and in acres.

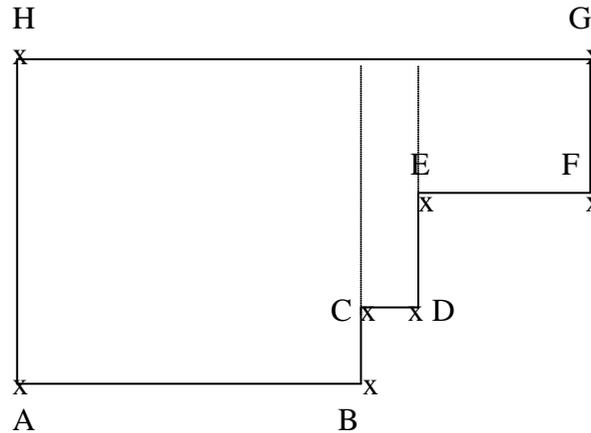


Given:

- | | |
|-----------|-----------|
| AB = 300' | EF = 200' |
| BC = 100' | FG = 250' |
| CD = 100' | GH = 600' |
| DE = 150' | HA = 500' |

Solution:

Break the field down into recognizable shapes and compute the area of each part:



Compute:

1. Area of rectangular section defined by connecting points
 $ABCC'HA = (AB)(HA) = (300)(500) = 150,000$ square feet.
2. Area of rectangular section defined by connecting points
 $CDEE'C'C = (CD)(DE + FG) = (100)(400) = 40,000$ square feet.
3. Area of rectangular section defined by connecting points
 $EFGE'E = (EF)(FG) = (200)(250) = 50,000$ square feet.
4. Add all of the parts to get the total area of the field:
 $\text{Area} = 150,000 + 40,000 + 50,000 = 240,000$ square feet.
5. Convert the area in square feet to acres:
 $\text{Area} = 240,000/43560 = 5.5$ acres.

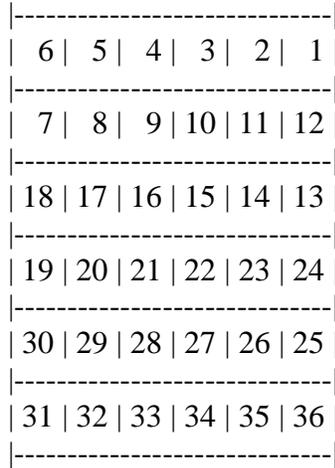
D. Land Description

1. The rectangular system of land survey is used in 30 western states in the U.S.
2. This system is based upon the following subdivisions:
 - a. Quadrangles are square tracts of land approximately 24 miles on each side.
 - b. Quadrangles are subdivided into 16 townships, each approximately 6 miles on a side.
 - 1) Townships are bounded on the north and south by township lines and on the east and west by range lines.

130U-15

c. Townships are subdivided into 36 sections, each approximately 1 mile on a side and containing 640 acres.

1) Sections are numbered by starting in the northeast corner and continuing west and east across the township as shown below: (also see page 130U-27)



d. Sections are subdivided into quarter-sections, each approximately 1/2 mile on a side and containing 160 acres.

e. Quarter-sections may be divided into fractional areas, the individual tracts containing 80, 40, 20, 10, or 5 acres or combinations of these.

f. Section descriptions must include the section number, range number, township number, and principle meridian (In Idaho the principle meridian is the Boise Meridian, BM)

Activity:

1. Fill in the land description on worksheet #1.

DIFFERENTIAL LEVELING

A. Mapping the Topography of a Field

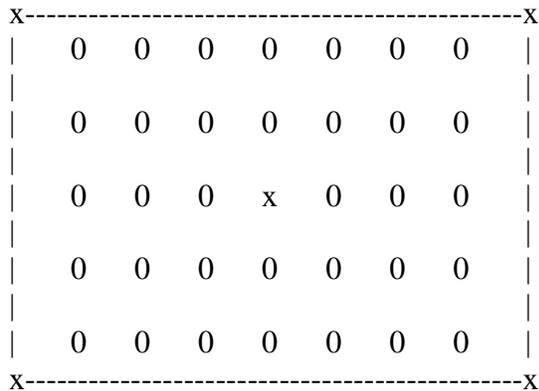
1. Purpose

- a. To determine the relative ground surface elevations of a tract of land and to plot those elevations on a base map.
- b. Completion of the above enables determination of cuts and fills to grade the land for an exact slope for surface irrigation.

2. Procedure

a. Staking the Field

- 1) Stakes should be set at equal distances across the field to be surveyed.
- 2) 3/8" x 1-3/4" x 4' lathes pointed at one end are commonly used.
- 3) A survey reading will be taken at each stake location in order to enable calculation of relative topography of the field.
- 4) A field set up with stakes might look like:



0 Stake location
x Level location

b. Setting and Reading the Level (See page 130U-xx)

- 1) The level should be set at the center of the field as indicated above.

- 2) The level should be set up and leveled as described previously or as described in the operator's manual for the level.
- 3) A level rod reading is taken at each stake location.
 - a) If the ground is soft, a tractor can be driven along the line of stakes and rod readings can be taken in the wheel tracks.
- 4) Differences in rod readings for each stake represent differences in elevation at each stake.
 - a) The rod reading itself represents the vertical distance from the ground at each stake to the level of the cross hair in the level instrument.
 - b) The relative elevation at a particular stake location is higher when the rod reading is small.
 - c) The relative elevation at a particular stake location is lower when the rod reading is large.

c. Recording Information

- 1) A rod reading is recorded for each stake in the field.
- 2) Rod readings should be recorded for a permanent reference point location (called a bench mark or BM) as well as at each corner of the field.
 - a) A benchmark is a marked point of known elevation. They should be marks that are easily recognized, easily found, and not likely to be moved. They can be cross marks or bronze tablets set in masonry in a good foundation or they can be a certain part of a fire hydrant, pump base, or nail in a tree.

d. Producing a Base Map

- 1) If the exact elevation of the reference BM is not known, it is common to assume it is 100 feet in elevation.
- 2) Add the rod reading at the benchmark to the elevation of the BM.
 - a) The resulting number is the elevation of the cross hair in the instrument.

- 3) At subsequent stakes, subtract the stake rod level reading from the number computed in paragraph 2). above.
- 4) The following map illustrates recording of the pertinent rod reading information:

x-----x					
	0	0	0	0	
	3.20	3.42	3.46	3.22	
	0	0	0	0	
	3.21	3.44	3.46	3.21	
	0	0	x 0	0	
	3.21	3.44	3.46	3.22	
	0	0	0	0	
	3.21	3.44	3.48	3.21	
	0	0	0	0	
	3.20	3.45	3.47	3.22	
BM-----x					

- 3.00' = height of instrument (cross hairs)
- 0 Stake location
- 3.22' Rod reading at each stake in feet
- x Level location
- BM Bench mark location = 100 feet (assumed)

- 5) The following base map represents the surveyed field with the elevations relative to the 100 foot BM.

Elevation of the cross hair = $100.00' + 3.00' = 103.00'$

$103.00 - 3.20 =$ 

x-----x					
	0	0	0	0	
	99.80'	99.58'	99.54'	99.78'	
	0	0	0	0	
	99.79'	99.56'	99.54'	99.79'	
	0	0	x 0	0	
	99.79'	99.56'	99.54'	99.78'	
	0	0	0	0	
	99.79'	99.56'	99.52'	99.79'	
	0	0	0	0	
	99.80'	99.55'	99.53'	99.78'	
BM-----x					

100.00'

130U-20

- 1) It is generally recommended that the distance from the instrument to the benchmark not exceed 400 feet; approximately 200 feet is the usually recommended distance.
 - 2) It is also recommended that the instrument be set up close to halfway between two benchmarks in order to cancel out leveling errors.
- c. Send the rodman to the BM and record the rod reading (3.02') at this point. This is what is known as a backsight (BS) reading and is recorded under BS in the field notebook.
- 1) A backsight (BS) reading is sometimes designated with a + sign and always results from a reading at a point of known or calculated elevation.
 - 2) Add the BS reading to the elevation of the BM to give the height of the instrument (HI), i.e., $HI = 3.02' + 100.00' = 103.02'$.

- d. Move the rodman to station TP-1, take a rod reading (3.68') and record this as a foresight (FS) reading in your field notebook.

- 1) Subtract this FS reading from the HI reading to obtain the elevation at point TP-1, i.e., $103.02' - 3.68' = 99.34'$.

Note that the process is repeated in steps e through g below

- e. Move the level instrument to the second level set-up location (X#2) and set up and level the instrument.

- f. Take another rod reading from X#2 back to TP-1. Record this backsight reading (3.34') in the field notebook.

- 1) Add the BS reading to the elevation of TP-1 to give the height of the instrument (HI), i.e., $HI = 3.34' + 99.34' = 102.68'$.

- g. Move the rodman to station TP-2, take a rod reading (4.17'), and record this as a foresight (FS) reading in the field notebook.

- 1) Subtract this FS reading from the HI reading to obtain the elevation at point TP-2, i.e., $102.68' - 4.17' = 98.51'$.

Note that the process is again repeated in steps h through j below.

h. Move the level instrument to the third level set-up location(X#3) and set up and level the instrument.

i. Take another rod reading from X#3 back to TP-2. Record this backsight reading (4.00') in the field notebook.

1) Add the BS reading to the elevation of TP-2 to give the height of the instrument (HI), i.e., $HI = 4.00' + 98.51' = 102.51'$.

j. Move the rodman to station TP-3, take a rod reading (3.95'), and record this as a foresight (FS) reading in the field notebook.

1) Subtract this FS reading from the HI reading to obtain the elevation at point TP-3, i.e., $102.51' - 3.95' = 98.56'$.

Note that the process is again repeated in steps k through m below.

k. Move the level instrument to the fourth level set-up location (X#4) and set up and level the instrument.

l. Take another rod reading from X#4 back to TP-3. Record this backsight reading (3.56') in the field notebook.

1) Add the BS reading to the elevation of TP-3 to give the height of the instrument (HI), i.e., $HI = 3.56' + 98.56' = 102.12'$.

m. Move the rodman to the original BM, take a rod reading (2.11'), and record this as a foresight (FS) reading in the field notebook.

1) Subtract this FS reading from the HI reading to obtain the elevation at point BM, i.e., $102.12' - 2.11' = 100.01'$.

FIELD NOTEBOOK FOR SURVEY

STATION	BS	HI	FS	ELEVATION
BM	3.02'	103.02'		100.00'
TP-1	3.34'	102.68'	3.68'	99.34'
TP-2	4.00'	102.51'	4.17'	98.51'
TP-3	3.56'	102.12'	3.95'	98.56'
BM			2.11'	100.01'
SUMS	+13.92'		-13.91'	

BS - FS CHECK = $+13.92' - 13.91' = +0.01'$

BM CHECK = $100.01' - 100.00' = +0.01'$

3. Checking for Survey Arithmetic Errors

- a. The backsight and foresight columns should be added separately and compared with the difference between the original and final benchmark elevations. The differences should be the same in numerical value and algebraic sign. If either error is present, there is a mistake in the addition or subtraction in the field notebook and the calculations should be refigured.
- b. Difference between the original BM1 elevation and the calculated BM1 elevation after a return check, if they fail to agree, this is know as an error of closure.

4. Rules of Differential Leveling

- a. All rod readings are recorded by both surveyors (rodman and level person) as soon as they are checked. All rod readings are recorded in the line that refers to the point sighted.
- b. All arithmetic is carried out as far as is possible with the readings available. The computations are made by each person while the other is moving.
- c. All work must stop until each person agrees on the elevation of each TP.
- d. The backsight and foresight columns should be added separately and compared with the difference between the original and final benchmark elevations. The differences should be the same in numerical value and algebraic sign.
- e. Every benchmark must be used as a turning point.

References:

Ruth, Lawrence O., & Field, Harry L. (1991) Introduction to Agricultural Education, 2ed, New York, Chapman & Hall

Bowers, W., Jones, B. A., Jr., & Olver, E. F. (1973). Engineering Applications in Agriculture. Champaign, IL: Stipes Publishing Company.

Kissam, Phillip. (1978). Surveying Practice (3rd ed.). New York: McGraw-Hill.

Special Materials and Equipment:

Steel tape, chaining pins, range poles, plumb bob, odometer, tripod level, hand level (clinometer). Steel tape, chaining pins. Tripod level, level rod, field notebook.

Name _____

Date _____

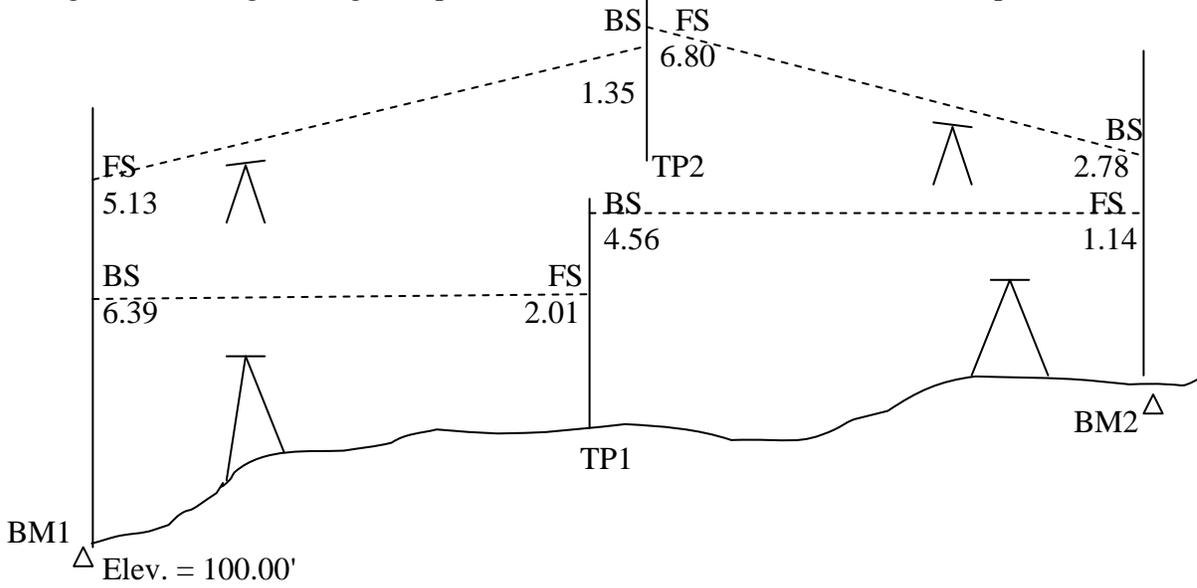
Score _____

SURVEYING, UNIT EXAM

Match the terms on the right to the correct definitions on the left by placing the appropriate letters in the blanks provided. (5 points each)

- | | |
|--|------------------------------|
| 1. _____ Elevation of the level line of sight or of the cross hairs in the telescope with respect to the bench mark. | A. Bench Mark (BM) |
| 2. _____ Level line through the instrument, as viewed by the eye; place where vertical hair crosses the horizontal hair. | B. Foresight (FS) |
| 3. _____ Method of determining the differences in elevation between two points. | C. Backsight (BS) |
| 4. _____ Permanent point of known or assumed elevation from which leveling surveys are started. | D. Height of Instrument (HI) |
| 5. _____ Book used to keep surveying information. | E. Error of Closure |
| 6. _____ Rod reading taken on a point of known elevation. | F. Field notebook |
| 7. _____ Rod used in leveling, normally graduated in tenths and hundredths of a foot. | G. Differential Leveling |
| 8. _____ Method of determining the elevation of a series of points at measured intervals along a line. | H. Profile Leveling |
| 9. _____ Rod reading taken on a point of unknown elevation. | I. Level Rod |
| 10. _____ Difference between the original BM1 elevation and the calculated BM1 elevation after a return check, if they fail to agree | J. Line of Sight |

Using the following reading, complete the field notes on the form below. (50 points)



STA	BS	HI	FS	ELEV
BM1				
TP1				
BM2				
TP2				
BM1				

Error = _____ - _____ = _____

Answer Sheet

Worksheet # 1

- A. NE 1/4, Sec17, T6N, R5E, BM
- B. SW 1/2, NW 1/4, Sec17, T6N, R5E, BM
- C. E 1/2, NW 1/4, Sec17, T6N, R5E, BM
- D. NE 1/4, SW 1/2, Sec17, T6N, R5E, BM
- E. NW 1/4, SW 1/4, SW 1/4, Sec17, T6N, R5E, BM

Worksheet #3

- 1. 6.17
- 2. 6.15
- 3. 6.14
- 4. 6.09
- 5. 6.06
- 6. 6.05
- 7. 5.97
- 8. 5.89
- 9. 5.85
- 10. 5.84

Unit Exam

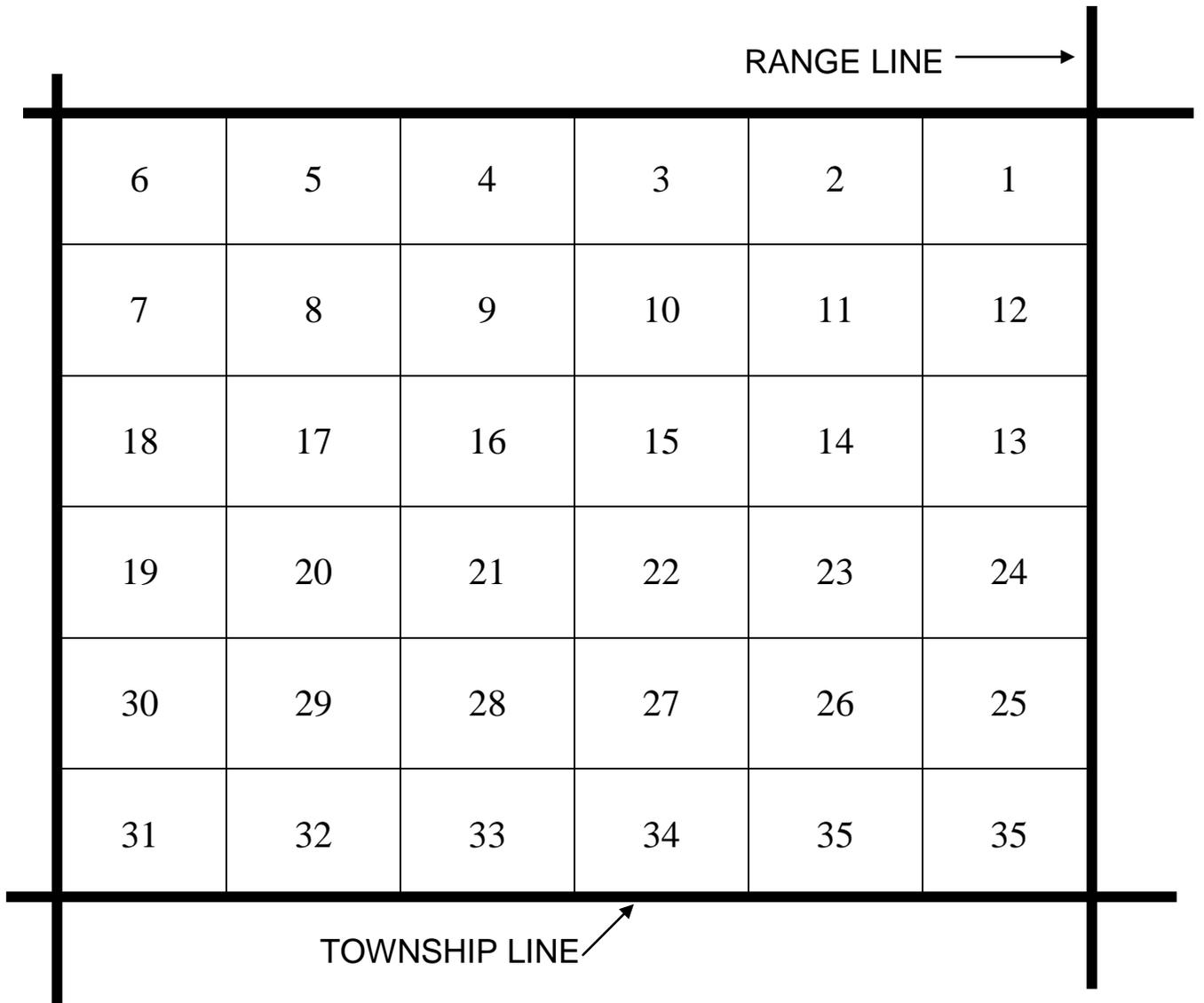
- 1. D
- 2. J
- 3. G
- 4. A
- 5. F
- 6. C
- 7. I
- 8. H
- 9. B
- 10. E

STA	BS	HI	FS	ELEV
BM1	6.39			100.00
		106.39		
TP1	4.56		2.01	104.38
		108.94		
BM2	2.78		1.14	107.80
		110.58		
TP2	1.35		6.80	103.78
		105.13		
BM1			5.13	100.00

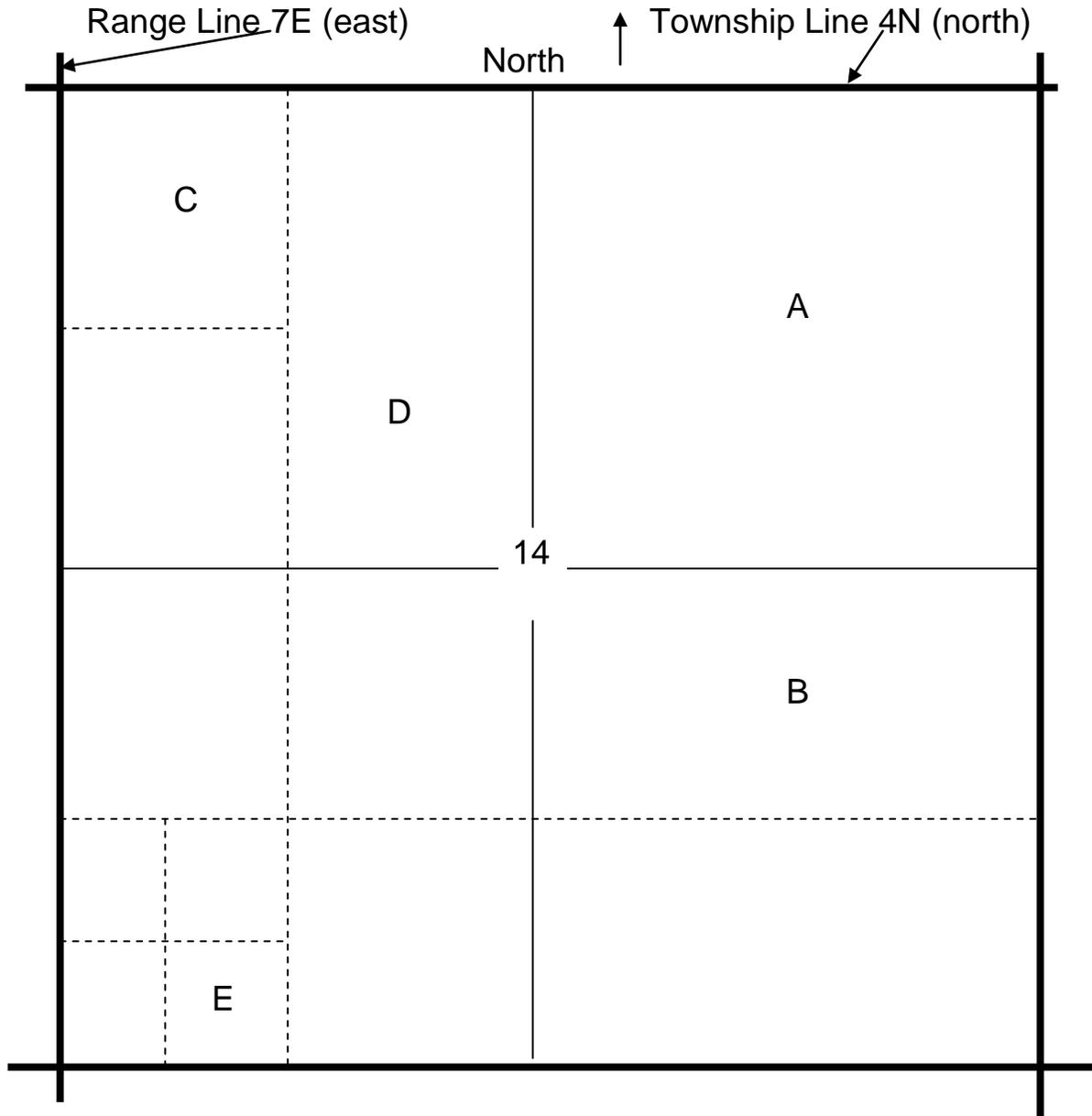
Error = $100.00 - 100.00 = 0.00$

130U-27

SUBDIVISION OF A TOWNSHIP



SUBDIVISION OF A SECTION



A = NE 1/4, S14, T4N, R7E, BM (BOISE MERIDIAN)

B = N 1/2, SE 1/4, S14, T4N, R7E, BM

C = NW 1/4, NW 1/4, S14, T4N, R7E, BM

D = E 1/2, NW 1/4, S14, T4N, R7E, BM

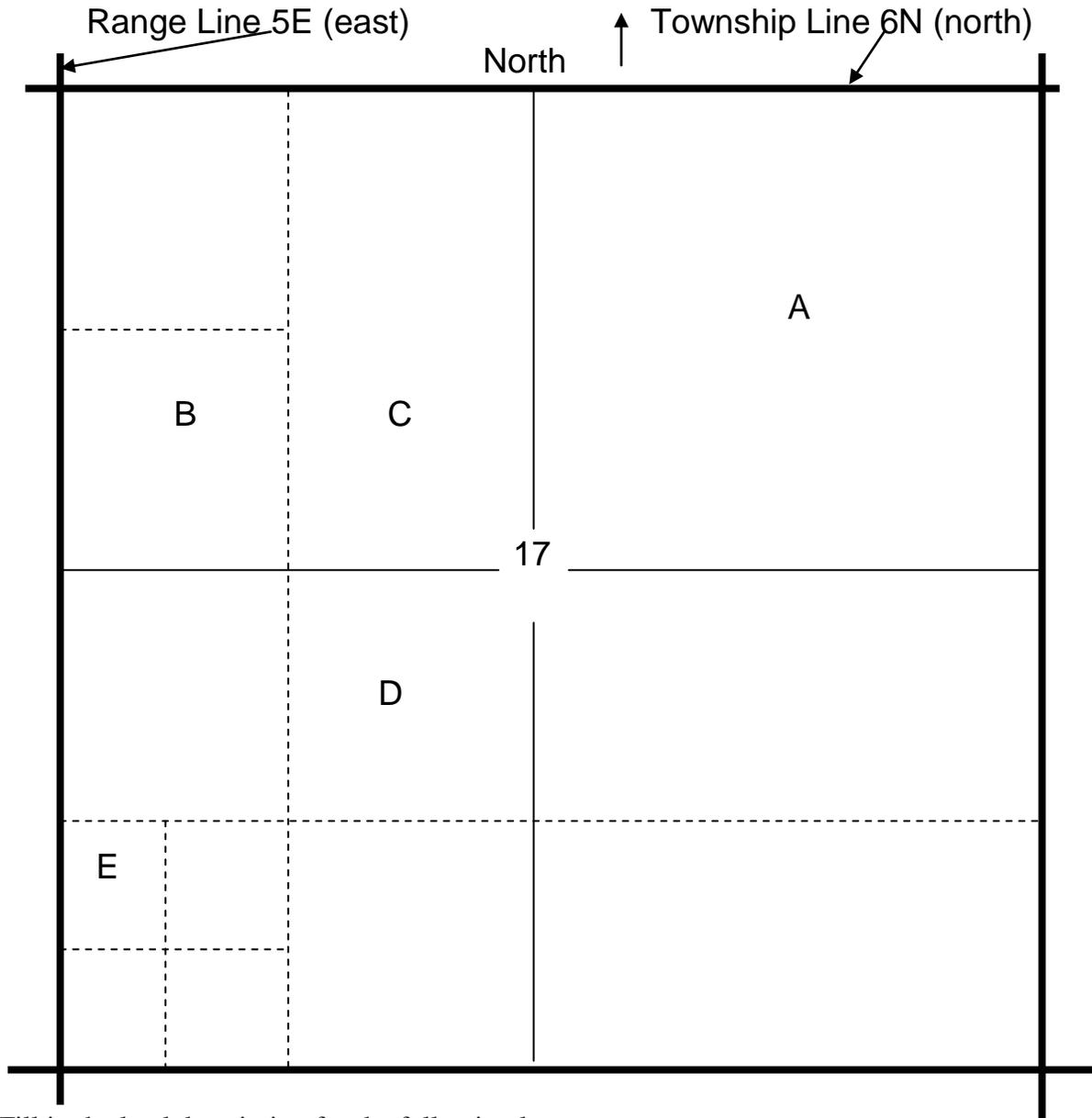
E = SE 1/4, SW 1/4, SW 1/4, S14, T4N, R7E, BM

Name _____

Date _____

Score _____

SUBDIVISION OF A SECTION



Fill in the land description for the following letters.

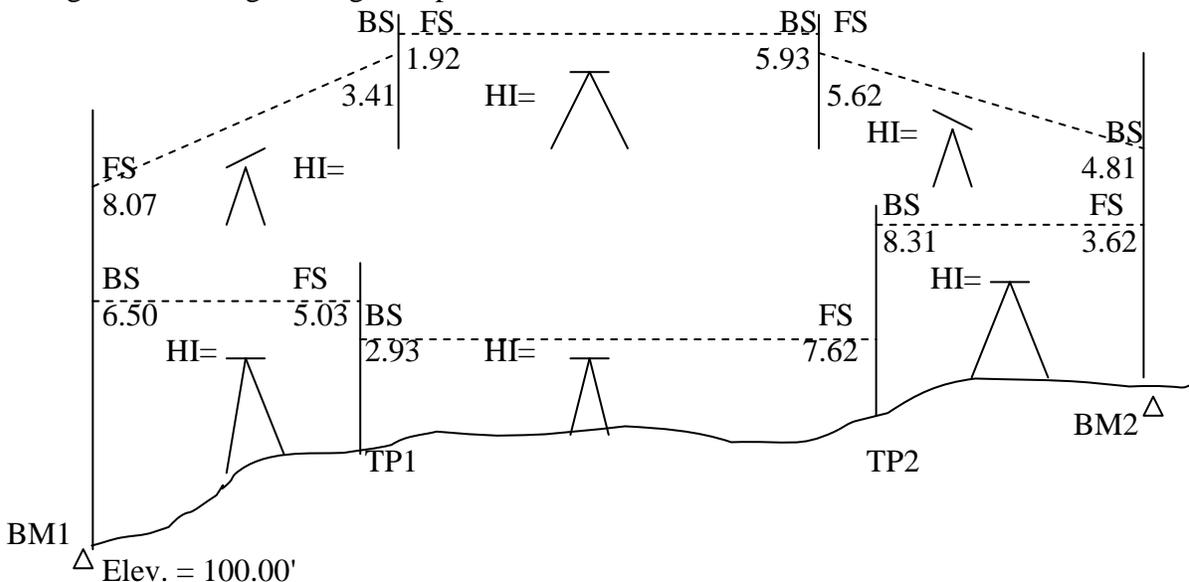
- A =
- B =
- C =
- D =
- E =

130U-30
Worksheet #2

Name _____
Date _____
Score _____

DIFFERENTIAL LEVELING PROBLEM

Using the following reading, complete the field notes on the form below.



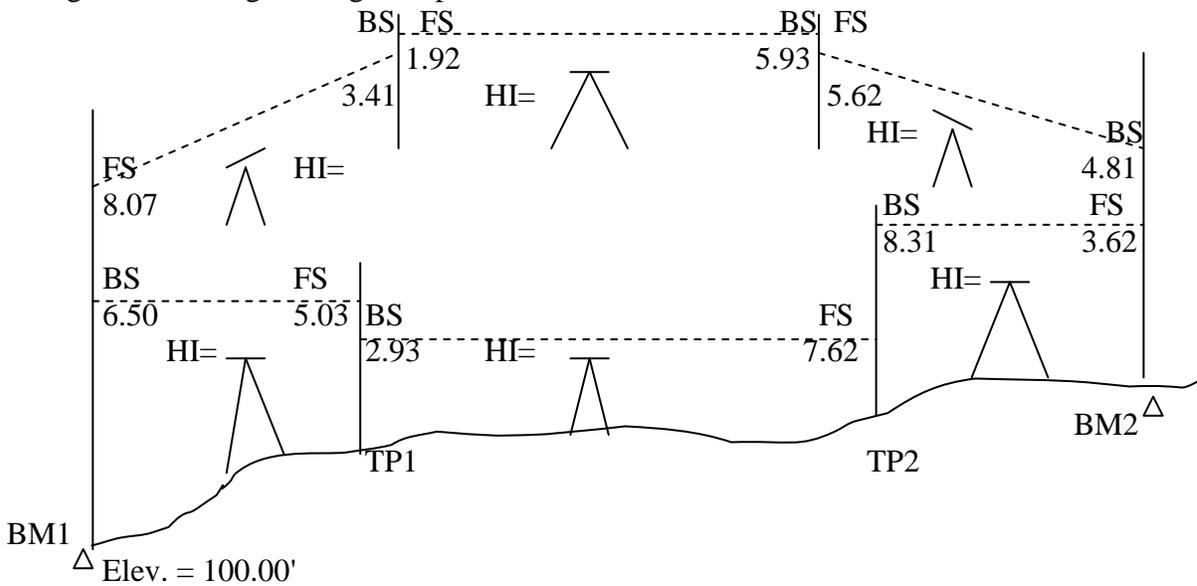
STA	BS	HI	FS	ELEV
BM1				
TP1				
TP2				
BM2				
TP3				
TP4				
BM1				

BM1 – 2ed BM1 = error

_____ - _____ = _____

DIFFERENTIAL LEVELING PROBLEM

Using the following reading, complete the field notes on the form below.



STA	BS	HI	FS	ELEV
BM1	6.50			100.00
		106.5		
TP1	2.93		5.03	101.47
		104.40		
TP2	8.31		7.62	96.78
		105.09		
BM2	4.81		3.62	101.47
		106.28		
TP3	5.93		5.62	101.66
		106.59		
TP4	3.41		1.92	104.67
		108.08		
BM1			8.07	100.01

(BM1) 100.00 – (BM2) 100.01 = 0.01 Error

130U-32

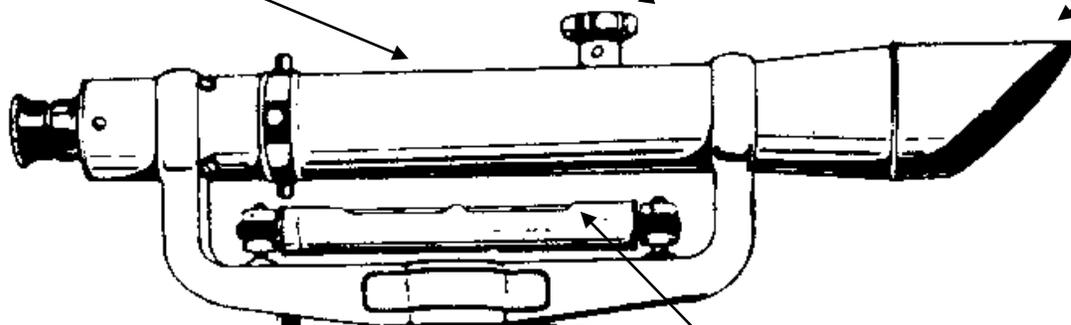
PARTS OF THE LEVEL

EYE PIECE

TELESCOPE BARREL

FOCUS SCREW

SUN SHADE

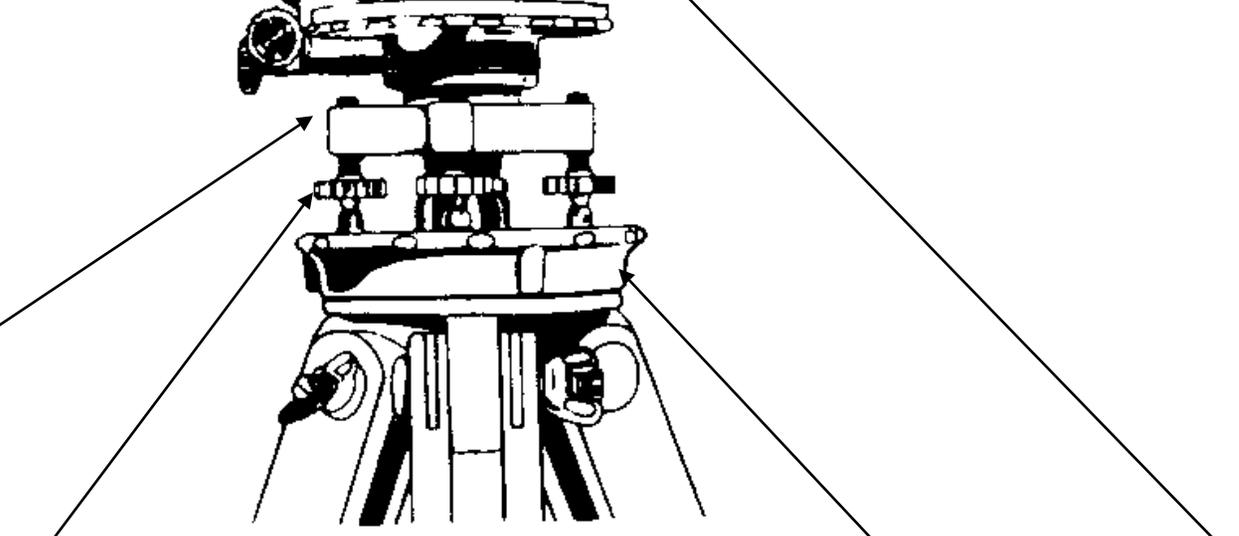


LEVELING HEAD

LEVELING SCREW

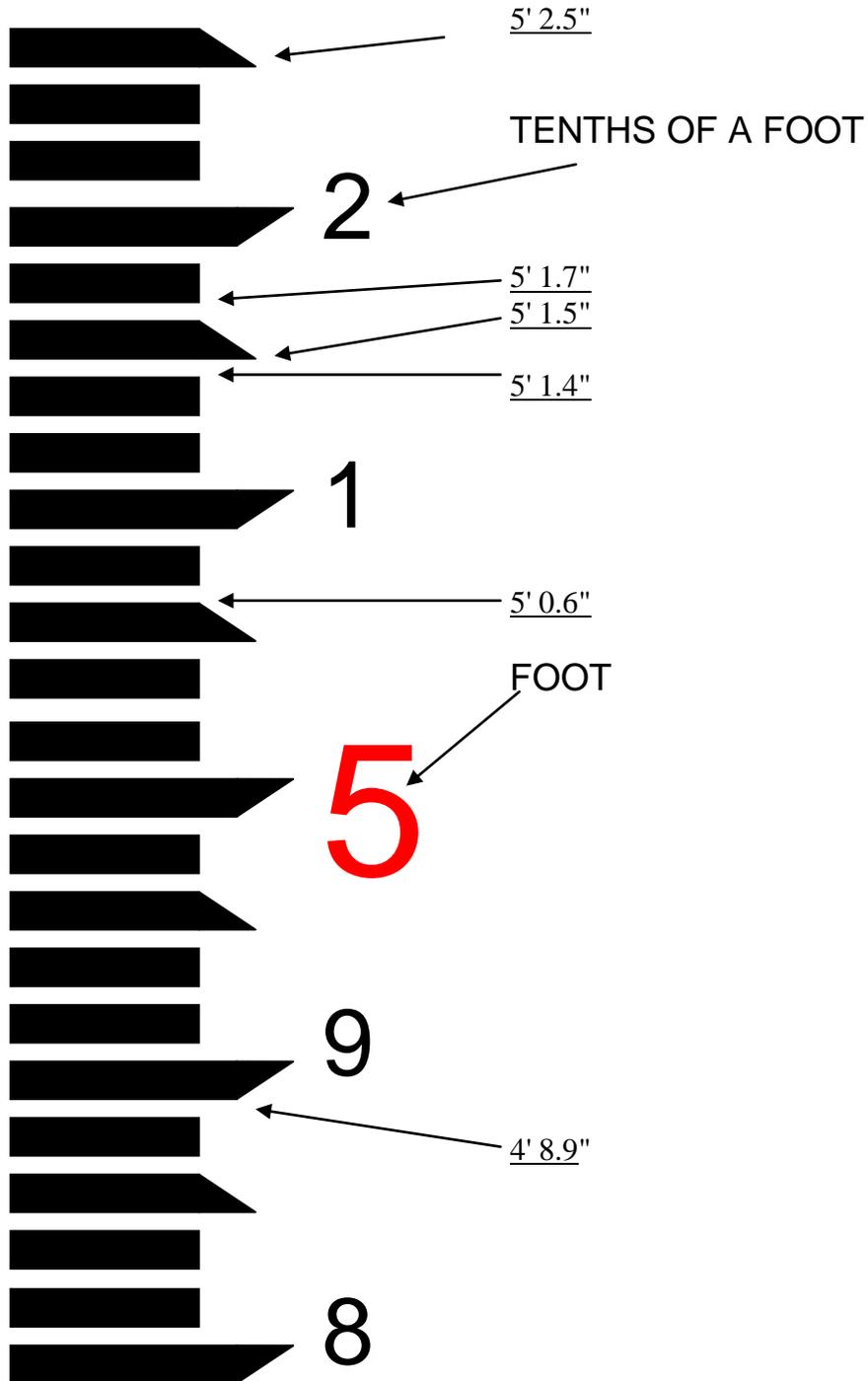
HEAD PLATE

BUBBLE TUBE



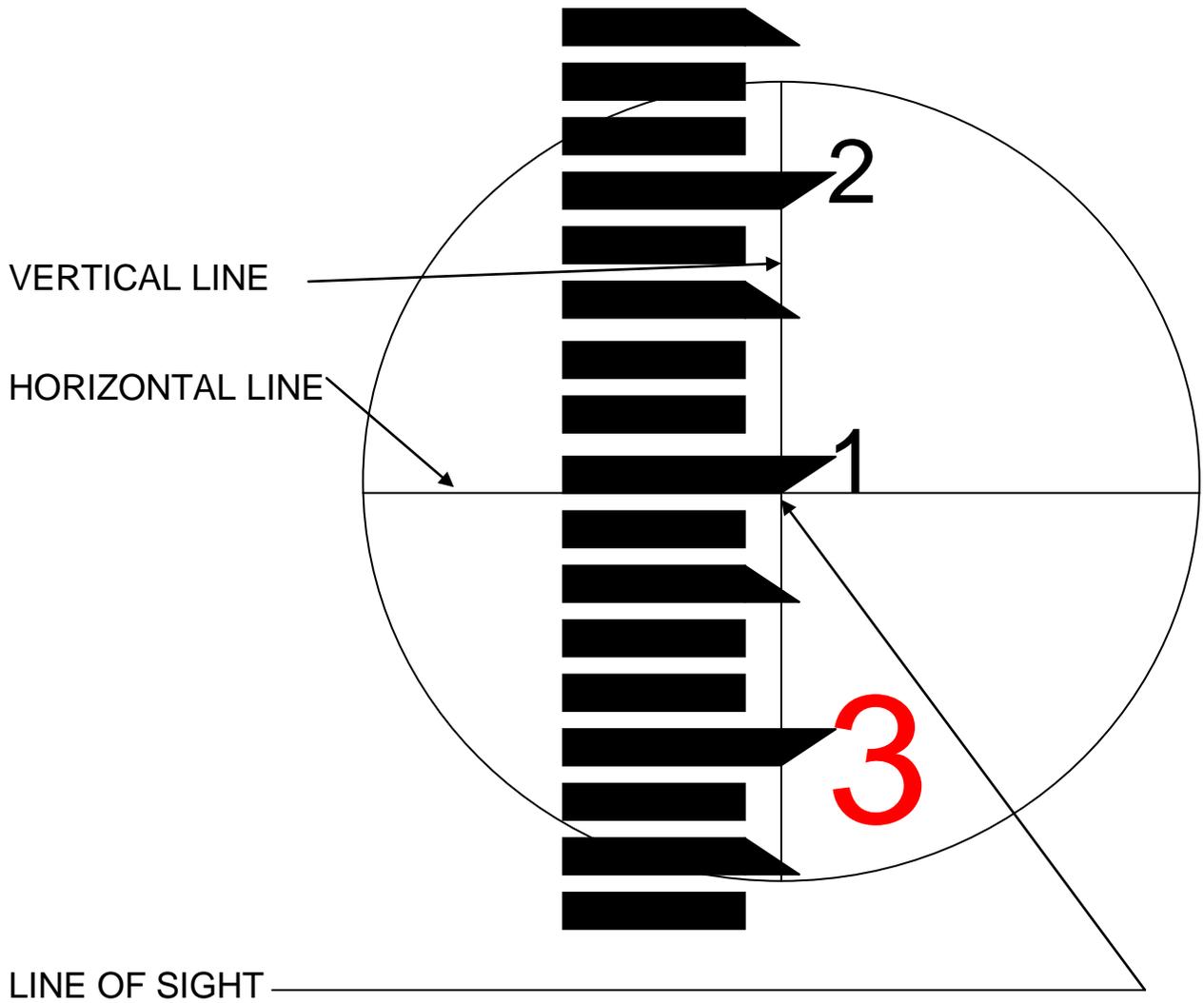
READING THE LEVELING ROD

Each corner and each point, is a point of measurement. There are 10 points of measurements between numbers.



CROSS HAIRS IN THE TELESCOPE

TAKING THE READING



Take the reading at the line of sight.
The reading on this level rod is 3.09 feet

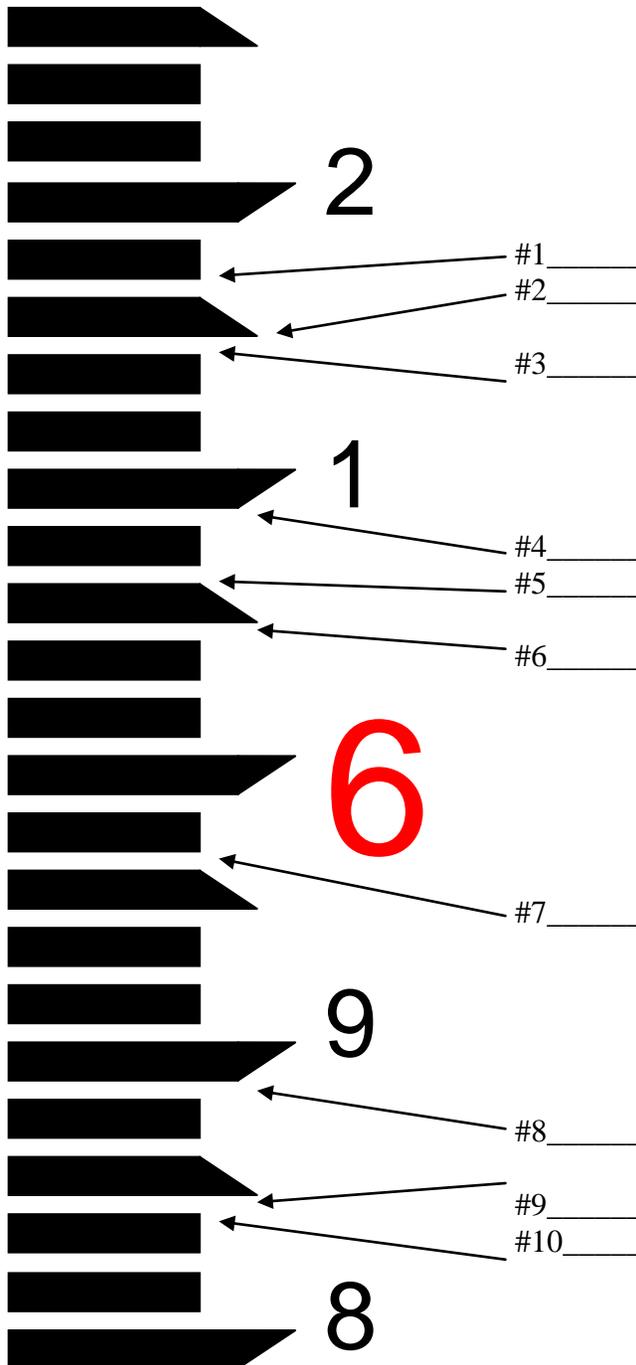
Name _____

Date _____

Score _____

Worksheet #3, Reading the Level Rod

Fill in the measurement reading in the blanks, answer questions to the nearest hundredths.



130V-1

CAREERS IN AGRICULTURAL MECHANICS

AG 130-V

UNIT OBJECTIVE

After completion of this unit, students will know and understand the different career opportunities available to them as high school graduates, two-year college graduates, and four-year college graduates.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Explain the importance of work to the individual and society.
2. Identify 12 potential agriculture or agriculture-related careers.
3. Identify 4 potential local agriculture or agriculture related careers.
4. Describe economic and technological trends which may affect the work environment.
5. Identify ways in which employees may have to adapt to a changing work environment.
6. Identify and describe a career interest in an ag or ag related occupation.
7. Analyze the skills, abilities and education required to gain entry into the students occupational choice.
8. Develop an appreciation for reasons workers could be fired from their jobs.

IMPORTANCE OF WORK

A. The Importance of Work to the Individual.

1. The "work ethic" is a code of values that says that work is good in itself. This idea originally came from the Pilgrims.
2. Our ancestors like the pilgrims and indians had to work to survive.
3. Working gives the individual a sense of pride and self worth.
 - a. If you have done your job to the best of your ability, you should be proud of that work, knowing that you are working to your potential.

B. The Importance of Work to Society.

1. Every occupation serves some purpose and is useful.
2. Individuals should value the work they do and respect work done by others.
3. New inventions, techniques and devices are created by individuals working together.
4. Work by individuals benefits our society and makes our country's economy stronger by contributing not only quality work, but spending your income to purchase the products of other American's work

AGRICULTURE CAREERS

A. Importance of Agriculture Careers

1. Approximately 1/2 of all workers in Idaho work in jobs directly or indirectly related to agriculture.
2. Remember that Idaho is number one in the nation in potato production, ninth (and still climbing) in dairy production. (Based on 1998 statistics.)
3. Agricultural occupations range from flower production to meat processing, providing a great variety of career options.

B. Career Areas

1. Ag careers can be grouped into 8 general career areas:
 - a. Production Agriculture: This involves actually raising field crops, poultry, fruit, vegetables, or livestock.

- b. Agriculture Mechanics: This involves planning and constructing buildings, machinery maintenance, welding, electrical work and plumbing.
- c. Agriculture Sales and Service: This involves occupations such as veterinarian, farrier, ag commissioner, equipment dealers, feed dealers, ag flying.
- d. Agriculture Processing: Involves processing and distributing food. Examples are butchers, egg processing, plant workers, cheese processing workers.
- e. Horticulture: Involves landscaping, floriculture, turf management, and nursery management.
- f. Forestry: Involves producing and harvesting timber, managing forests and reforestation .
- g. Rural Recreation and Natural Resources: Involves working with renewable resources such as wildlife, water and soil.
- h. Agricultural Marketing and Business Management: Involves business economics related to agriculture, developing markets for agricultural products and successful marketing of those products.

C. Local Careers

1. Careers available in agriculture in your area depend upon different factors including:
 - a. Population: rural areas have more production ag and urban areas usually have more processing and horticulture.
 - b. The climate and rainfall influences crops and livestock produced in the area; which may affect availability of certain supplies and services.
 - c. Consumer demand - may influence the types of crops grown and types of ag employment available.
2. Your career choice should be reflected in your choice of SOE.
For example:
 - a. a lamb, beef or swine production SOE project would be of great benefit if your career goal is to be livestock producer.
 - b. a work experience SOE in a feed store or vet clinic would benefit if you plan a career in sales and service or marketing and management.
 - c. Building an equipment trailer would benefit someone who wanted a career in ag mechanics.

ACTIVITY:

1. Read chapter 1 in the FFA Student Handbook on Careers.
2. Have students make up a bulletin board displaying different careers in ag in your local area.

TRENDS IN CAREER OPPORTUNITIES

I. Economic trends in Agriculture

A. Ag careers are affected by changes in the agriculture economy.

1. Consumer preferences: as consumer tastes and desires change so do the career opportunities available.
 - a. For example: Poultry production and processing careers have expanded due to the health conscious consumer choosing poultry over beef and pork.
2. Imports: as we import goods, this changes career opportunities available.
 - a. For example: Sheep and lamb production has declined in the US due to cheaper imports from countries such as Australia and New Zealand.
3. Surpluses: when more raw materials are produced than are consumed we have a surplus. This often leads to new uses for this product.
 - a. For example: Gasahol was partially developed to utilize our surplus grains.
4. Government Support: Some crops and livestock receive price supports and this may create interest in that area.

B. Technological Trends in Agriculture

1. Ag careers have expanded due to great changes in technology. However, this same technology has out-dated many types of ag labor.

130V-5

- a. Mechanization: this type of technology utilizes machine power to replace human and animal power.
- b. Computerization: has streamlined many farm operations.
 - 1) For example: Nutritionists utilize computers to develop balanced rations for livestock.
- c. Biotechnology has allowed rapid changes in new crop developments.
 - 1) For example: Genetic engineering and plant tissue culture have improved our crops dramatically.
- d. Continued Education: now more than ever before, because of technology advanced training either through formalized education or in depth on-the-job training is required for many ag occupations.

ACTIVITY:

1. Ask local agribusiness people to discuss with the class what they are looking for in an employee today as compared to 10 years ago.
2. Discuss how jobs in Ag have changed over the last 20 years and where careers in ag will shift in the future.

CHOOSING A CAREER GOAL

- A. Education requirements differ with the career you choose. Here are some types and examples of education beyond high school.
 1. Vocational Institutes: Train students in areas such as diesel mechanics or horse shoeing. Courses are intensive and rely heavily on practical experience and may be completed in 1 year.
 2. Community colleges provide continued education to prepare students to go on to a university or receive enough training in certain areas to obtain jobs.
 - a. A larger variety of classes can be taken than at a Vocational Institute.
 - b. A program of study is generally completed in 2 years.

3. State colleges and universities require 4 years to complete and allow students opportunities to obtain employment in areas such as engineering, education, nutrition and economics.
 - a. A 4 year degree can broaden job opportunities and increase wage earning power.
 - b. A degree of this type can lead into graduate work to obtain an advanced degree such as PhD, MD, DVM or MBA.

JOB RELATED ETHICS

A. Introduction

1. Ethic: " a philosophy or systems of morals; ethics" It is a code of behavior, or an idea of how one should act in a situation.
2. Ethics related to your job mean the code of behavior you follow for work. Examples of job related ethics could include:
 - a. Showing up on time to work
 - b. Never taking a longer break than you are supposed to
 - c. Not "borrowing" tools and equipment that are not yours to borrow
 - d. Not using the company telephone to make long distance calls to friends just to visit.
3. What is the value of possessing job related ethics?
 - a. It may help you keep your job. (For those who constantly abuse the rules and regulations, long term employment at one place may not ever happen.)
 - b. Those who live within the rules of the job and remain honest and responsible will earn the respect of their co-workers and employers.
 - c. Even more important, this kind of person has respect for him/herself. This can mean a lot in productivity, job satisfaction, and **JOB PROMOTION!**

DOING YOUR JOB WELL

A. Introduction

Once you have obtained a job you must keep it. There are two things you should consider when thinking about keeping your job, the first is how you might evaluate your own performance and the second is to consider how or why workers are fired from their jobs, and see to it that you avoid such habits and attitudes yourself.

B. Why do people lose their jobs? There are many reasons, here are a few:

1. late for work;
2. make costly mistakes, or break things, or abuse and break tools;
3. laziness, that is, they just don't try very hard, or move very fast;
4. If they are working with the public, they are impolite, inattentive; or otherwise treat the paying customer badly;
5. do not follow the directions of the supervisors and/or employer;
6. don't get along or cooperate with fellow workers;
7. not making an effort to learn on the job;
8. talking about the company in a negative manner to friends, co-workers, and customers;
9. not dressing appropriately for the job;
10. not using initiative, needing to be told constantly what is to be done (usually goes along with laziness);
11. depending on co-workers to perform tasks that you should do; and
12. calling in with excessive excuses for missing work, "my car broke down, I can't make it in," (truthfully - I just didn't feel like coming in today) or "I'm really sick today" (truthfully - there is a great sale at Macy's that I just can't miss), etc.

C. Am I a good employee? It comes down to five questions:

1. Am I working to the best of my ability? When you say you have done a job or task to the best of your ability, are you telling the truth?
2. Am I honest with my boss and myself? If you tell the boss you are sick, are you truly sick?
3. Am I fair to my boss and my fellow workers and treat them with the respect they deserve? Do you give them the same respect you would like to receive, and not indulge in idle chatter and gossip about co-workers or the employer?
4. Am I representing myself and my employer favorably with the public (or whomever you work with). Do you meet the public politely and cheerfully, and try to make sure the customers are satisfied?
5. Am I using or abusing the privileges extended to me by my employer? This could include breaks, discounts on goods, sick days, etc.?

Activities:

1. Describe a situation in which an employee who is in sales offends a customer by telling the customer that what he/she is buying is not suitable, (use any item you choose, landscape plants, livestock feed, tools, etc). Have two students role play and have the class offer suggestions on how the situation might be handled in a positive manner.
2. Have students make up a list of employee behaviors which might cause customers and/or employers to become angry. Opposite each situation, list another behavior which might make the customer and/or employer less angry.
3. Set up a panel discussion with three employers in the area. Ask them to each comment on what it takes to be a productive employee, how they handle occasional and persistent lateness on the job, how they go about hiring and firing, and the reasons for hiring and firing. This panel could be set up in the multi-use room and other students could be invited (part of an employment fair, career day, etc, or at least try to obtain release time for all agriculture students to attend. Have them each summarize the important points and turn it in for grading.

CAREER OPPORTUNITIES IN WELDING

A. Welders in American Industry

1. There are over 550,000 welders employed in American industry
2. Approximately three fifths of welders work in industries that manufacture equipment for construction, agriculture, transportation, and households. The remainder work in repair shops and construction.

B. Career Requirements and Outlook

1. The demand for qualified welders is increasing in Idaho. Experienced welders are needed in equipment manufacturing, construction, and repair in nearly every major industry.
2. Education and essential skill upgrading are requirements for top employment as a welder. This educational training varies from a few months of on-the-job training to several years of formal training. The key skill is to be able to weld at a high quality level.
3. Welders need to be free of any physical problems that would prevent them from bending and working in awkward positions. Good eyesight and steady eye-hand coordination are required. Welders frequently have to spend long periods of time on detailed work.
4. Qualifications/Certification

130V-9

- a. If a welder does any type of code work, he/she must pass a series of qualifying tests in order to become certified.
- b. These qualifying procedures are designed to meet a set of standards that mainly deal with work quality. In order to pass qualifying examinations, the welder must produce test welds that indicate a mastery of the technical skills of various types of welds.

Activity:

1. Visit local welding shops and observe the types of welds being done and the types of equipment being used. Report on the adequacy or inadequacy of safety practices employed by working welders.
2. Visit a welding supply store to determine the types of equipment readily available and the costs of this equipment.

Reference: "

A Practical Manual for Job-Hunters and Career Changers: What Color is Your Parachute?" by Richard Nelson Bolles

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3ed EDITION. Albany, NY: Delmar Publishers.

Agricareers <http://www.agricareers.com>

Gives a listing of ag jobs that are available in the ag industry, good for career lesson plan

Agco, <http://www.agcocorp.com/>

The AGCO site offers a lot of educational information about tractors and implements.

The site also gives the history of the AGCO corporation.

John Deere Employment Opportunities, <http://www.deere.com/ag/agtech/techprgm.htm>

This site contains pages on how to get into John Deere ag. mechanics programs in different colleges.

Lincon Electric, <http://www.lincolnelectric.com/>

Welding Safety, Etc. (Order free poster)

American Welding Society, <http://www.amweld.org/>

A wealth of welding information, links to other related sites.

Hobart Institute of Welding Technology, <http://www.welding.org/>

Order materials on-line.

Caterpillar, <http://www.cat.com>

Caterpillar tractor information and news and latest equipment

Agsafe, http://www.agsafe.org/series_1/machine.html

Ag safety news and updates

Detroit Diesel <http://www.detroitdiesel.com/welcome.htm>

Talks about the Detroit motor and all the products that they deal with

Lumber, <http://www.lumber.com>

Talks about forest products and what is made from trees good for forestry lesson or plant science

Freightliner, <http://www.freightliner.com>

Good site to get info off of for a diesel or ag mech. class lots of engine info

130V-11

Grainger <http://www.grainger.com>

Order book for mechanical supplies gives prices and little info on some tools

Denison Hydraulics <http://www.denisonhydraulics.com>

Lots of info on hydraulic systems and how they work plus schematics

HECO <http://www.heco.net>

Motor and pump company that gives info on what else motors and pumps

Fannosaw, <http://www.fannosaw.com>

Website that talks about all the different types of pruning saws good for tool identification

Reliance, <http://www.reliance.com>

Information on everything from electricity to motors to drive systems

UDOR, <http://www.udor.com>

Pumps for ag and also has schematics on some pump parts

Rainbird, <http://www.rainbird.com>

Irrigation and services of rainbird and any info you need on sprinklers, etc.

Agrisurf, <http://www.agrisurf.com> meta site link for access to other sites dealing with Ag.

Trimble, <http://www.trimble.com>

Deals with the GPS system for farming to make it easier for the farmer, just info on GPS.

New Holland, <http://www.newholland.com>

Deals with their equip and their co.

Vickers, <http://www.vickers-systems.com>

Deals with hydraulics

Sears, <http://www.sears.com>

Many sites, can go to projects get ideas

130W-1

INTRODUCTION TO OXYACETYLENE WELDING & CUTTING

AG 130-W

UNIT OBJECTIVE

After completion of this unit, students will be able to operate oxyacetylene welding and cutting equipment safely and demonstrate basic oxyacetylene welds and cutting procedures. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Pass a safety test on oxyacetylene welding.
2. Identify the basic components of the oxyacetylene welder apparatus.
3. Set up, use, shut off, and store an oxyacetylene welder properly.
4. Use the oxyacetylene equipment to braze mild steel.
5. Run a bead with the oxyacetylene equipment with and without filler rod.
6. Select welding rods and fluxes appropriate for the job.
7. Clean the orifices in welding heads using the approved technique.
8. Use the oxyacetylene equipment to perform three basic fusion welds.
9. Make a straight cut, using the cutting head.
10. Make a bevel cut, using the cutting head.
11. Pierce a hole in steel plate.
12. Clean the orifices in welding and cutting heads, using the approved technique.
13. Cut sheet metal (14 ga. or thinner) with the cutting head.

OXYACETYLENE WELDING EQUIPMENT AND SAFETY

A. Oxyacetylene Equipment Identification

1. Gas Cylinders

a. Oxygen Cylinders

1) Oxygen

- a) Oxygen is a colorless gas (20% of the atmosphere).
 - b) Oxygen has no smell or taste.
 - c) Oxygen is not a flammable or toxic gas.
 - d) Oxygen readily supports combustion.
- 2) Common size oxygen cylinders hold about 244 cu. ft. of oxygen at 2,000 to 2,600 lbs. per square inch (psi) pressure.
 - 3) Because of their high pressure, they can explode if dropped, struck, heated, or arced with an arc welder.
 - 4) The cylinder valve, which allows the flow of gas from the cylinder to the regulator, is protected when not in use with a threaded cylinder cap.
 - 5) The cylinder cap has two holes on its side designed to cause a cylinder with a broken-off valve to spin instead of take off like a missile from the jet effect of the escaping, high pressure gas.

b. Acetylene Cylinders

1) Acetylene

- a) Acetylene is a colorless gas (a compound of carbon and hydrogen).
- b) Acetylene has a pungent smell due largely to impurities.
- c) Acetylene is flammable and highly explosive when mixed with oxygen.
- d) Acetylene is explosive when compressed above 15 psi, but is very soluble in acetone.
- e) Acetylene forms explosive compounds with silver and copper, so never use copper pipe or fittings with it.

130W-3

- 2) Acetylene cylinders are filled with a porous form of concrete in which all the air is removed by filling the pore spaces with acetone.
- 3) The acetylene can be stored in these cylinders at pressures above 15 psi without becoming unstable because it combines with the acetone under pressure.
- 4) Large acetylene cylinders can hold around 275 cu. ft. of acetylene at 250 psi.
- 5) If acetylene is withdrawn too quickly, removing all the available acetylene, the cylinder pressure gauge will read empty; but after the cylinder is not used for a while, more usable acetylene will come out of the solution.
- 6) Acetylene cylinders must be kept upright for about eight hours before use and during use in order to prevent acetone loss.

2. Gas Regulators

- a. Gas regulators reduce the high cylinder pressures to low, hose pressures suitable for welding and cutting applications.
- b. Identification of the Parts of a Gas Regulator

1) Inlet (cylinder valve connection)

- a) Oxygen inlets have right-handed threads.
- b) Acetylene inlets have left-handed threads and their nuts are notched on the outside.

2) Pressure Adjusting Screw

- a) Decreasing the pressure (out) is counterclockwise.
- b) Increasing the pressure (in) is clockwise.

3) Cylinder (high) Pressure Gauge

- a) Oxygen cylinder gauge reads 0-4000 psi.
- b) Acetylene cylinder gauge reads 0-400 psi.

4) Working (low) Pressure Gauge

- a) Oxygen working gauge reads 0-200 psi.
- b) Acetylene working gauge reads 0-30 psi.

5) Outlet (connection for hoses)

- a) Oxygen outlets have right-handed threads.
- b) Acetylene outlets have left-handed threads.

3. Check Valves

- a. Check valves allow the gases to flow in only one direction to prevent backflow.
- b. Check valves are necessary safety devices attached between the hoses and the regulator outlets.

4. Gas Hoses

- a. The hoses transport low-pressure gas from the regulator to the torch.
- b. The oxygen hose is always black or green.
- c. The acetylene hose is always red.
- d. The hoses are flame retardant, but should still be kept away from an open flame, sparks, molten metal, and slag.
- e. New hoses are stored with talcum powder inside, which should be blown out before connecting them to the torch.

5. Torch (Blowpipe)

- a. The torch controls the mixture of oxygen and acetylene to produce the desired flame.
- b. Identification of the parts of the torch:

1) Hose connections

- a) Oxygen connection is usually marked "OXY."
- b) Acetylene connection is usually marked "FUEL."

2) Oxygen control valve

3) Acetylene control valve

4) Barrel

5) Torch head

6. Torch Tips

- a. Welding tips
- b. Cutting tips
- c. Heating tips
- d. Tip cleaner

7. Protective Wear

- a. Goggles
- b. Leather gloves

8. Striker

- a. Hand-held piece of equipment used to produce spark.

9. Working Surfaces

- a. Welding table (fire brick does not explode under heat)
- b. Cutting table

B. Oxyacetylene Welding Safety

1. Preventing Eye Injury

- a. Wear goggles with the proper lens when welding, cutting, and grinding.
- b. Protect others' vision by using a welding shield.
- c. Make sure no one is standing in front of the cylinder valve before cracking it to prevent eye injury from blowing dust and grit.
- d. Make sure no one is standing in front of the gas regulators when turning them on to prevent injury from flying glass should they explode.

2. Preventing Burns

- a. Wear protective gloves, clothing, and boots (lace-up shoes can trap hot sparks, molten metal, and slag).
- b. Use a spark striker for lighting a torch, not matches or heated metal.
- c. Cool in water or mark your work "HOT" to keep others from touching it.
- d. Do not wear ragged clothes or cuffs on pants.
- e. Keep gloves and protective clothing free of oil and grease.

3. Preventing Respiratory Problems

- a. Ventilate the work area properly.
- b. Do not breathe the toxic fumes from welding or cutting galvanized material.

4. Preventing Equipment Damage

- a. Always use gas regulators to protect the hoses from the high cylinder pressure.
- b. Use tongs not the leather gloves to pick up hot metal.
- c. Do not over tighten hose connections and torch tips.
- d. Never lift cylinders by their valves.
- e. Never weld or cut on concrete; overheated concrete cracks and explodes.
- f. Be careful not to break tip cleaners off in the tip being cleaned.
- g. Keep hoses clear of the torch flame and dropping, molten metal when cutting.

5. Preventing Fire & Gas Explosions

- a. Never light a torch in an area full of feed or grain dust.
- b. Keep the area between you and the cylinders clear and the cylinder valves unobstructed.
- c. Keep oil and grease away from oxygen and oxygen connections.
- d. Do not try to find a gas leak with a flame; use soapy water from a soap that does not contain oil.
- e. Do not weld or cut on closed containers, tanks, or vessels.
- f. Never leave a lighted torch unattended.
- g. Never use the oxygen tank as a pressure supply to inflate tires or blow off surfaces.
- h. Always make sure the safety chain is attached and hold onto the oxygen cylinder when moving the cylinder truck.
- i. When moving or storing individual cylinders, always replace the caps to prevent valve damage.

ACTIVITY:

1. Identify all the components of an oxyacetylene welder.
2. Change lenses on welding goggles.
3. Take an oxyacetylene safety test.

OXYACETYLENE WELDING EQUIPMENT SET-UP & ADJUSTMENT

A. Oxyacetylene Equipment Setup

1. Cylinders

- a. Place the oxygen and acetylene cylinders side by side in a vertical position and secure them from falling.
- b. Remove the cylinder valve protection caps and store them for reuse later when the cylinders are empty.
- c. Check the cylinder valve threads to verify that they are in good condition and free of dirt and oil.
- d. Briefly "crack" the cylinder valves (slightly open) to blow out any dust or dirt that may be lodged there, so it does not enter the regulators.

2. Regulators

- a. Verify that the regulator inlet connection is free of dirt, oil, grease, or any other obstruction.
- b. Connect the oxygen and acetylene regulators to the proper cylinder valves using an open-end wrench, being careful to tighten the connection nut firmly without excessive force.
- c. Turn the regulator adjusting screw out (counterclockwise) on each regulator until it is loose.
- d. Stand to one side of the oxygen regulator gauge and open the oxygen cylinder valve slowly so the high-pressure regulator gauge needle gradually moves up to approximately 2000 psi if the cylinder is full, then open the valve completely.
- e. Slowly open the acetylene cylinder valve only one half turn, so it can be turned off quickly in an emergency. Acetylene cylinders read about 350 psi when full.

3. Hoses and Torch

- a. Connect the oxygen hose (green) to the oxygen regulator outlet and the acetylene hose (red) to the acetylene regulator outlet.
 - 1) The oxygen hose has right-handed thread connections.
 - 2) The acetylene hose has left-handed thread connections.
- b. Blow out the hoses with cylinder gas to remove dust, dirt, and talcum powder (used to protect new hoses in storage), which may plug the small gas passages in the torch.

130W-8

- 1) Turn the adjusting screw on the regulators clockwise until 5 psi shows on the low (working) pressure gauge.
 - 2) Allow the cylinder gas to escape until the inside of the hoses are clean.
- c. Connect the free end of the oxygen hose to the torch connection marked "OXY" and the free end of the acetylene hose to the torch connection marked "FUEL."
 - d. Select the tip or nozzle size appropriate for the metal thickness (see welding tip selection chart), and only hand-tighten the tip to the torch.
 - e. Test for leaks by pressuring the system (described in paragraph B-1 below) and then brushing a non-detergent, soapy water on all the connections.
 - 1) Soap bubbles will indicate a leak; also listen for the hiss of escaping oxygen and try to discern the smell of acetylene.
 - 2) If a leak is found in a connection, retighten it or replace the faulty connection.
 - 3) Leaking cylinders should be returned to the supplier.

B. Adjusting the Torch

1. Pressurizing the System

- a. Close both control valves on the torch handle clockwise, finger tight only.
- b. Verify that the regulator screws are turned out and loose.
- c. Standing to one side of the regulator, slowly open the oxygen cylinder valve until the pressure gauge responds, and then open the valve all the way.
- d. Slowly open the acetylene cylinder valve 1/2 turn or one turn of the wrist.
- e. Open the torch oxygen valve 1/8 turn and then screw in the oxygen regulator valve until the desired working pressure is indicated on the regulator working pressure gauge. Close the torch oxygen valve.
- f. Open the torch acetylene valve 1/8 turn and then screw in the acetylene regulator valve until the desired working pressure is indicated on the regulator working pressure gauge. Close the torch acetylene valve.

2. Lighting and Adjusting the Torch

- a. Be sure all-protective clothing and goggles (No. 5 shaded lens) are on before proceeding to light the torch.
- b. Hold the torch in one hand and the striker (spark lighter) in the other.
- c. Open the torch acetylene valve no more than 1/4 turn and ignite the gas with the striker.
- d. Open the torch acetylene valve until the flame is no longer smoking.
- e. To set a carbonizing flame (excess amount of acetylene):
 - 1) Open the torch oxygen valve until a feathered cone exists in the flame.
 - 2) Three flame zones are present. They are the inner cone, the acetylene feather, and the outer envelope.
- f. To set a neutral flame (equal amounts of oxygen and acetylene):
 - 1) Open the torch oxygen valve until the acetylene feather disappears and only the inner cone and outer envelope exist.
 - 2) When the feathery edges of the inner cone disappear, a neutral flame is present.
- g. To set an oxidizing flame (excess amount of oxygen):
 - 1) Open the torch oxygen valve beyond a neutral flame to a point where the flame is pale blue.
 - 2) The inner cone will be shorter, will become slightly pointed, and the flame will be more noisy than the neutral flame.

C. Oxyacetylene Equipment Shut-down and Storage

1. Torch Shut-down:

- a. First, turn off the torch acetylene valve. If a small flame remains on the tip, the acetylene valve is leaking.
- b. Turn off the torch oxygen valve last.

2. Depressurize the system:

- a. Close both cylinder valves.

130W-10

- b. Open the torch acetylene valve to depressurize the acetylene gauges and hose.
- c. Close the torch acetylene valve.
- d. Open the torch oxygen valve to depressurize the oxygen gauges and hose.
- e. Close the torch oxygen valve.
- f. Turn out the adjusting screws on the oxygen and acetylene regulator valves.

3. Storage of Cylinders

- a. Store cylinders in a well-ventilated, fireproof room or cage with flameproof electrical fittings.
- b. Do not store oxygen and combustible gases such as acetylene together.
- c. Store acetylene cylinders in an upright position--liquid acetone from within the cylinder can leak into valves.
- d. Write "empty" with chalk or soapstone on empty cylinders and keep them separate from full cylinders.
- e. Store cylinders away from sources of heat, since heat increases the pressure of gas and may weaken the cylinders.
- f. Store cylinders away from oil and grease, since these combustibles may ignite spontaneously when in contact with pure oxygen.
- g. Keep the cylinder caps on cylinders while in storage to prevent cylinder valve damage, which could result in an oxygen cylinder taking off like a missile.

ACTIVITY:

1. Set up oxyacetylene equipment.
2. Select a tip size using a tip chart.
3. Pressurize the system and light a torch.
4. Adjust for carbonizing, neutral, and oxidizing flames.
5. Dismantle the oxyacetylene equipment and put the cylinders in storage.

OXYACETYLENE FUSION WELDING

A. Oxyacetylene Fusion Welding Definition and Applications

1. Definition

- a. Fusion welding is the joining of metal pieces by melting them together.
- b. This is accomplished by heating the adjoining edges of metal to their melting point, allowing them to flow together, and then cool to harden as one piece.
 - 1) The combustion of the oxygen-acetylene gas mixture provides the heat for fusion.
 - 2) The flame from the combustion shields the weld from atmospheric contamination.
 - 3) A filler rod may be used to provide additional metal to help the two metal pieces join.
 - 4) The basic skill required in fusion welding is to form, maintain, and move a puddle of molten base metal along the weld, keeping it uniform in both size and shape.

2. Applications

- a. Fusion welding is used extensively for joining steel.
- b. Oxyacetylene fusion welding is usually applied only to thin steel.

B. Oxyacetylene Welding Terminology

1. Forehand Welding

- a. The filler rod precedes the torch in the direction of the weld.
- b. The filler rod and torch tip are both manipulated in opposite rotating directions.
- c. This is the best technique for welding metal up to 1/8 inch thick.

2. Backhand Welding

- a. The torch tip precedes the filler rod in the direction of the weld.
- b. Little or no manipulation of the torch tip and filler rod is required.
- c. This is the best technique for welding metal over 1/8 inch thick.

3. Welding Angles

- a. Work angle is the angle of the torch or filler rod perpendicular to the direction of the welding bead.
- b. Lead angle is the angle of the torch or filler rod parallel to the direction of the welding bead.

4. Base Metal (the metal to be welded)

5. Filler Rod

- a. It is a rod or wire of filler metal of the same composition as the base metal.
- b. A mild steel rod is used to weld mild steel; an aluminum rod is used to weld aluminum, etc.
- c. The diameter of the filler rod should equal the thickness of the base metal or bead.

6. Bead is the appearance of the finished weld, normally viewed as neat ripples formed by the metal while it was in its semiliquid state.

7. Tack Weld

- a. Tack welds are small, spaced welds along the weld joint made before running the continuous bead along the same joint.
- b. Tack welds prevent expansion or contraction of the weld joint during continuous welding.

C. Oxyacetylene Fusion Welding Procedures

1. Running a bead without filler rod (pushing a puddle)

- a. Prepare a piece of mild steel 1/8 inch thick.
- b. Use an 0 or 00 welding tip.
- c. Adjust the working pressures to about 3 psi for acetylene and 10 psi for oxygen.
- d. Wear appropriate protective gear, then light and adjust the torch to a neutral flame.
- e. Hold the torch at a 90 degree work angle and a 30 degree to 45 degree lead angle, with the inner cone of the flame 1/16 to 1/8 inch above the base metal.
- f. Hold that position over a spot just inside the right edge of the base metal until a molten puddle is established.
- g. Move the torch in a series of arcs or circles to make the puddle circular in shape and about 1/4 inch in diameter.

- h. Advance the torch from right to left across the base metal at a speed that will maintain a uniform puddle size and shape.
 - 1) If advanced too rapidly, the puddle will become too small and may be lost completely.
 - 2) If advanced too slowly, the puddle will become too large and may burn through the base metal.

2. Running a Bead with a Filler Rod

- a. The steps are the same as above until the molten puddle is formed.
- b. Once the puddle is formed, dip the end of the 1/16 inch diameter steel filler rod into the puddle and begin moving the torch in a series of vertical ovals, while at the same time moving the rod up and down, in and out of the puddle.
 - 1) As the flame rises, the rod lowers, and vice versa.
 - 2) Do not allow molten metal to drip from the end of the filler rod, but add the filler metal directly by dipping the end of the rod into the puddle.
- c. As the torch is advanced from right to left, maintain uniform bead width and height with a smooth ripple effect.
 - 1) If advanced too rapidly, the bead will become narrow and have the appearance of having been deposited on top of the base metal.
 - 2) If advanced too slowly, the bead will become too large and may burn through the base metal.

D. Oxyacetylene Welding Problems

1. Backfire (popping noise)

- a. Backfire is a momentary burning back of the flame into the tip ending with a loud pop (explosion at the tip).
- b. The causes can include the following:
 - 1) Insufficient gas velocity (open torch valves more).
 - 2) Overheated tip (hold tip farther away from the work or change the lead angle).
 - 3) Inadvertently moving the torch tip into the molten puddle (clean out the tip).

130W-14

- 4) Sparks flying into the tip.
- 5) Improper seals or grommets within the torch (examine and replace).

2. Flashback (popping with shrill squealing or hissing)

a. Flashback is an explosion occurring at the tip accompanied by gases burning back into the hoses and regulator.

b. The symptoms are as follows:

- 1) The flame goes out with a pop.
- 2) A loud squealing or hissing noise occurs.
- 3) Black smoke and sparks emerge from the tip.

c. The action required to remedy the problem is as follows:

- 1) Quickly close the torch valves and shut down the regulators and cylinder valves; allow the apparatus to cool.
- 2) Do not relight until the cause has been found and remedied

d. Possible causes could be any of the following:

- 1) Clogged tip
- 2) Improper oxygen-acetylene gas mixture ratio
- 3) Loose connections
- 4) Kinked hose

ACTIVITY:

1. Make a bead with and without a filler rod.

OXYACETYLENE BRAZING

A. Brazing

1. Brazing is the bonding (adhesion), rather than fusing (melting) of two metal objects.
2. This adhesion connection is made with a minimum of alloy (bronze) which melts above 800 degrees Fahrenheit and flows by capillary motion between close-fitting metal.
3. Brazing differs from braze welding in the following ways:
 - a. Brazing requires a very thin joint, as when overlapping sheet metal.
 - b. Braze welding joints resemble those of fusion welding; there is more bonding metal at the joint as compared to brazing.
4. Brazing can be used to join dissimilar metals.
5. Brazing can be used to join thin pieces of metal in order to decrease the danger of melting through.
6. Brazing can be used on most commercial metals, where oxyacetylene welding may have limitations.

B. Brazing Equipment

1. Brazing uses the same welding apparatus as oxyacetylene welding.
2. Flux required for bronze or brass brazing is usually a borax type consisting of sodium borate with other additives. (Flux is any substance or mixture used to promote the fusion of metals or minerals, for example, alkalis, borax, lime, fluorite, etc.)
 - a. Flux removes all oxides from the metal surfaces to be welded.
 - b. Flux forms a protective coating over the heated metal surfaces that prevents oxidation.
 - c. Flux floats the oxides and their impurities with which it combines to the top of the molten metal.
3. Bronze filler rods come in different sizes and have a lower melting point than the metal being bonded depending on their alloy composition.
 - a. Silicon bronze is used for copper sheet and mild steel.
 - b. Nickel bronze is used for mild steel, cast iron, and wrought iron.

C. Operating the Oxyacetylene Equipment to Braze and Braze Weld

1. Basic Brazing Technique:

- a. Set up the metal pieces to be joined.
- b. Select the appropriate torch tip.
- c. Adjust the torch to the appropriate gas pressures.
- d. Put on appropriate protective goggles and gloves.
- e. Light the torch with the striker and adjust the flame to slightly oxidizing.
- f. Heat the bronze filler rod with the torch flame and dip it in the flux so that it becomes coated with flux.
- g. Heat the area on the metal to be bonded to a cherry red color and "tin" it by applying a light coating of fluxed filler rod.
- h. After "tinning," finish the braze or braze weld by filling in the joint with a non-fluxed filler rod.

2. Brazing and Braze Weld Demonstrations

a. Overlap Joint (Brazing)

- 1) Overlap two pieces of sheet metal by approximately 1/4 inch.
- 2) Using the proper gas pressure and flame adjustment, "tin" the joint.
- 3) After "tinning," go back over the joint with a non-fluxed filler rod to smooth the joint.

b. Fillet Joint (Braze Welding)

- 1) Set up the two pieces of sheet metal at right angles.
- 2) Using the proper gas pressure and flame adjustment, "tin" the joint.
- 3) After "tinning," go back over the joint with a non-fluxed filler rod to smooth the joint.

ACTIVITY:

1. Bond sheet metal by brazing.
2. Bond mild steel plate by braze welding.

FOUR BASIC OXYACETYLENE FUSION WELDS

A. Corner Weld Without Filler Rod

1. Place two pieces of mild steel (1/16 inch thick) so that their edges form a 90 degree angle with their inside corners touching.
2. Select the appropriate tip by consulting a tip chart.
3. Adjust the working pressures to about 5 psi for oxygen and 5 psi for acetylene or according to manufacturer's recommendation for tip.
4. Wear appropriate protective gear, then light and adjust the torch to a neutral flame.
5. Tack weld the two pieces together:
 - a. Hold the torch at a 90 degree work angle and a 45 degree lead angle with the inner cone of the flame 1/16 to 1/8 inch above the base metal.
 - b. Place the torch over the two edges of the joint just inside the right corners of the base metals until a single molten puddle is established.
 - c. Remove the flame to allow the puddle to solidify.
 - d. Make another tack weld at the opposite end of the joint.
6. Play the flame on the right-hand tack weld to remelt a puddle on its surface, then advance the puddle from right to left along the joint at a speed that will maintain a uniform puddle size and shape.

B. Bead weld with filler rod:

1. Prepare a piece of mild steel 1/8 inch thick.
2. Select the appropriate tip by consulting a tip chart.
3. Adjust the working pressures to about 5 psi for oxygen and 5 psi for acetylene or according to manufacturer's recommendation for tip.
4. Wear appropriate protective gear, then light and adjust the torch to a neutral flame.
5. Hold the torch at a 90 degree work angle and a 45 degree lead angle with the inner cone of the flame 1/16 to 1/8 inch above the base metal.
6. Hold the filler rod in the outer part of the flame away from the joint until two tiny molten puddles begin to form on the corners, then add some filler metal from the rod to bridge the two puddles.
7. Continue to heat the puddle and add filler metal until the puddle is about 1/4 inch in diameter, then remove the flame to allow the puddle to solidify.
8. Using a forehand technique, advance the puddle from right to left at a speed that will maintain a uniform puddle size and shape.

9. Make sure that the filler rod is added only to the puddle, not just melting onto the pieces.

C. Butt weld with filler rod:

1. Prepare two pieces of mild steel 1/8 inch thick.
2. Select the appropriate tip by consulting a tip chart.
3. Adjust the working pressures to about 5 psi for oxygen and 5 psi for acetylene or according to manufacturer's recommendation for tip.
4. Wear appropriate protective gear, then light and adjust the torch to a neutral flame.
5. Tack weld the two pieces together so that they are spaced about 1/8 inch at the left and 1/16 inch at the right to allow for normal expansion from heating.
 - a. Hold the torch at a 90 degree work angle and a 45 degree lead angle with the inner cone of the flame 1/16 to 1/8 inch above the base metal.
 - b. Play the torch over the two edges of the joint just inside the right edges of the base metals until a molten puddle is established.
 - c. Hold the filler rod in the outer part of the flame away from the joint until two tiny molten puddles begin to form on the corners, then add some filler metal from the rod to bridge the two puddles.
 - d. Continue to heat the puddle and add filler metal until the puddle is about 1/4 inch in diameter, then remove the flame to allow the puddle to solidify.
 - e. Make another tack weld at the opposite end of the joint.
6. Play the flame on the narrower, right-hand tack weld to re-melt a puddle on its surface, then add metal from the filler rod.
7. Using a forehand technique, advance the puddle from right to left along the joint at a speed that will maintain a uniform puddle size and shape.
 - a. Make sure that the puddle melts into both pieces of metal at all times.
 - b. Make sure that the filler rod is added only to the puddle, not just melting onto the pieces.

D. Metal Behavior Under Applied Stress

1. Stresses are internal forces set up in the welded pieces due to heating and cooling.
2. Two types of stresses result from the welding process:

130W-19

- a. Stresses that develop while the weld is being made but which disappear on cooling.
 - b. Stresses that remain after the weld has cooled off (residual stresses).
3. There are several factors that affect distortion and residual stresses:
- a. Distortion (warping of the welded part) occurs if the expansion due to heating is resisted.
 - b. A residual stress results if the contraction due to cooling is resisted. Residual stresses can result in cracking of the welded part.
4. Methods of Reducing Distortion:
- a. Decrease the welding speed and use the smallest flame possible to obtain the correct penetration and fusion of metals.
 - b. Line up the work at a slight angle opposite the direction of distortion during cooling to ensure correct alignment.
 - c. Use skip or step-back method of welding.
 - d. Use clamps to prevent movement.
5. Methods of Reducing or Relieving Stress
- a. Run the weld bead from the fixed end to free end.
 - b. Use the round end of a ball peen hammer to peen the weld lightly as it cools.
 - c. Heat treat the welded material and then allow slow cooling

ACTIVITY:

1. Perform a corner weld without filler rod and have students practice the weld.
2. Perform a bead weld and butt weld with filler rod and have students practice the welds.

OXYACETYLENE CUTTING

A. Oxyacetylene Cutting Process and Applications

1. Oxyacetylene Cutting Process:

- a. Oxyacetylene cutting is a rapid oxidation or burning of metal at high temperature.
- b. Oxidation is the combining of oxygen with any other substance
 - 1) When oxygen slowly combines with a substance, the process is called oxidation.
 - 2) When oxygen rapidly combines with a substance, the process is called burning.
- c. This rapid oxidation process is accomplished by gas flame accompanied by a jet action which blows the oxides away from the cut.

2. Oxyacetylene Cutting Applications:

- a. The process can be applied to all carbon steels up to 0.25% carbon.
- b. The process can also be applied to higher carbon steels, but only with some difficulty.
- c. The process cannot be applied to copper, aluminum, or high-nickel alloys.

B. Oxyacetylene Cutting Equipment

1. Basic oxyacetylene welding apparatus with a cutting torch attachment is used for cutting.
2. Cutting torch valves:
 - a. Cutting torch (blow pipe) oxygen and fuel valves
 - 1) The fuel valve adjusts the flow of acetylene into the preheat section of the cutting torch attachment.
 - 2) The oxygen valve on the welding torch (blowpipe) is left fully open to supply the attachment with both preheat and cutting oxygen.
 - b. Cutting torch attachment preheat-oxygen valve

130W-21

- 1) This valve adjusts the flow of oxygen into the preheat section of the cutting torch attachment.
- 2) Oxygen is supplied through a different tube than that which supplies the cutting-oxygen valve.

c. Cutting torch attachment cutting-oxygen valve

- 1) This valve injects pure oxygen into the cut when its lever is depressed.
- 2) The resulting jet action greatly increases combustion and removes the molten metal and oxides from the cut.

3. Cutting Tip

- a. It is designed to accommodate both an oxyacetylene preheat flame and a jet stream of pure oxygen for cutting.
- b. It has smaller holes surrounding a larger center orifice.

- 1) The small holes direct the mixed gases into the preheat flame.
- 2) The larger center orifice permits the jet action of pure oxygen from a separate oxygen tube in the attachment.

c. The tip should be cleaned regularly as it becomes clogged with metallic particles during use.

- 1) Use a tip cleaner that is equal to or smaller in size than the tip holes.
- 2) Use an up-and-down motion; do not twist the tip cleaner in the tip holes.

C. Oxyacetylene Cutting Equipment Setup and Operation

1. Cutting Equipment Setup

- a. Attach the cutting attachment to the welding torch and hand tighten the fittings.
- b. Select the proper cutting tip size for the job and inspect the taper cone seat to be sure it is not damaged and is free of dirt.
- c. Insert the cutting tip into the tip nut, screw it onto the cutting attachment, and then tighten it with the appropriate wrench.

2. Cutting Torch Pressurization

- a. Loosen pressure adjusting screws on the regulators.

130W-22

- b. Open the oxygen cylinder valve slowly and completely.
- c. Acetylene cylinder valve.
 - 1) Open the valve slowly one half turn (one turn maximum).
 - 2) Never use over 15 psi.
- d. Open the torch (blow pipe) oxygen valve completely.
- e. Set working pressures according to tip size with the gas flowing.
 - 1) Set the recommended oxygen hose pressure by opening the preheat oxygen valve and adjusting the pressure with the oxygen regulator screw.
 - 2) Set the recommended acetylene hose pressure by opening the torch acetylene valve and adjusting the pressure with the acetylene regulator screw.
- f. Purge (blow out) the cutting oxygen passages by depressing the cutting torch oxygen lever before lighting the torch.

3. Cutting Torch Lighting and Adjustment

- a. Open the acetylene valve 1/2 turn and light the torch tip.
 - 1) Add acetylene until the smoke stops and the flame is about 1/8 inch from the tip.
 - 2) Reduce the acetylene until the flame touches the tip.
- b. Open the preheat oxygen valve on the attachment and adjust to a neutral flame.
- c. Depress the cutting-oxygen lever and readjust to a neutral flame.

4. Cutting Equipment Shutdown

- a. Close the preheat valves.
 - 1) Close the preheat-oxygen valve on the attachment first to avoid popping.
 - 2) Then close the acetylene valve on the torch (blow pipe).
- b. Close both cylinder valves.
- c. Open the acetylene valve to bleed the acetylene gauges, hose, and torch, and then close it.

- d. Open the preheat-oxygen valve on the attachment to bleed the oxygen gauges and hose, and to purge the torch.
- e. Loosen the regulator adjustment screws.

D. Oxyacetylene Cutting Procedure

1. Cutting a straight line

- a. Set the metal to be cut on a cutting table and mark a straight line on it with soapstone or clamp a length of angle iron on the line to guide the tip.

- 1) For a perpendicular cut, place one side of the angle iron on the surface of the metal so that the other side forms a 90-degree angle to the surface.
- 2) For a bevel cut, place the edges of the two outside surfaces of the angle iron on the metal surface so the surface aligned with the cutting line forms a 45-degree angle.

- b. Select appropriate cutting tip size for metal thickness.
- c. Adjust gas pressures according to tip size selected.
- d. Light torch and adjust flame.
- e. Hold the torch with one hand and guide it with the other, keeping the preheat cone 1/16 to 1/8 inch above the metal surface.
- f. Heat the edge of the metal to a cherry red.
- g. Depress the cutting-oxygen lever slowly.
- h. When the cut starts, continue it by moving the cutting tip along the line keeping the preheat cones just above the metal surface.

1) Cutting angle to direction of travel

- a) For thick metal, the preheat cones are kept perpendicular to the direction of travel.
- b) For thin metal, the preheat cones are slightly angled in the direction of travel.

2) Cutting speed

- a) Moving too slow will allow the metal to refuse at the bottom of the cut.
- b) Moving too fast will cause the metal edges to lose heat and halt the cut.

130W-24

- h. If the cut is lost, release the cutting-oxygen lever and reheat the metal before proceeding.

2. Piercing holes

- a. Preheat the spot by keeping the preheat cones slightly above the metal surface.
- b. Lift the torch slightly and slowly depress the cutting-lever.
- c. Tilt the torch slightly to blow the sparks away.
- d. Continue to feed cutting oxygen onto the spot until the hole is pierced in the metal.

ACTIVITY:

1. Identify which metals can be cut with an oxyacetylene torch.
2. Select appropriate cutting tip, gas pressures, flame for metal size being cut.
3. Cut a straight line in 1/8 and 1/2 inch mild steel plate.
4. Make a straight bevel cut in 1/2 inch mild steel plate.
5. Cut sheet metal (14 gauge or less).
6. Pierce a hole in 1/8 inch mild steel plate.

References:

Cooper, Elmer L. (1987). *AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS*. Albany, NY: Delmar Publishers.

Resources:

Deere & Company. (1987). *WELDING (6th ed.) (Fundamentals of Service (FOS) Series)*. Available from: John Deere Technical Services, Dept. F, John Deere Road, Moline, IL 61265 (Available in Spanish)

Special Material and Equipment:

Oxygen and acetylene cylinders, regulators and hoses, torch, tips, open-end wrench, striker, gloves, goggles, and protective clothing filler rods, 1/8 & 1/16 inch mild steel.

Name _____

Date _____

Score _____

UNIT EXAM, OXYACETYLENE WELDING AND CUTTING

Answer the following true and false questions, T if the statement is true and F if the statement is false.

1. _____ A pop will always be heard if the torch acetylene is turned off first when shutting down the torch.
2. _____ Acetylene outlets have a right-handed threads.
3. _____ Acetylene is very soluble in acetone.
4. _____ Gas regulators increase low cylinder pressure to high hose pressure.
5. _____ The pressure adjusting screw on a gas regulator should be turned counterclockwise (out) to decrease the pressure.
6. _____ Keep gloves and protective clothing free of oil and grease to avoid combustion if oxygen comes into contact them.
7. _____ Fumes from a cutting or welding galvanized metal are toxic.
8. _____ Cylinders may be lifted by their valves if care is taken not to drop them.
9. _____ The oxygen tank may be used as a pressure supply to inflate tires or blow off surfaces as long as a acetylene is not mixed.
10. _____ Use soapy water from a soap that does not contain oil to find gas leaks.
11. _____ Never cut or weld on concrete because overheated concrete may crack and explode.
12. _____ In an oxidizing flame, the inner cone will be shorter and the flame will be more noisy than the neutral flame.
13. _____ A bead may be run without a filler rod.
14. _____ Brazing uses the same welding apparatus as oxyacetylene welding.
15. _____ Bronze filler rods usually have a higher melting point than the metal being bonded.

Match the following descriptions with the best possible answer.

- | | | |
|-----------|--|-------------------------|
| 16. _____ | Joining metal pieces by melting them together. | A. Work angle |
| 17. _____ | The filler rod precedes the torch in the direction of the weld | B. Oxidation |
| 18. _____ | The torch tip precedes the filler rod in the direction of the weld. | C. Backfire |
| 19. _____ | The angle of the torch or filler rod perpendicular to the direction of the welding bead. | D. Flashback |
| 20. _____ | The angle of the torch or filler rod parallel to the direction of welding bead | E. Fusion Welding |
| 21. _____ | The momentary burning back of the flame into the tip ending in a loud pop (explosion at the tip) | F. Backhand Welding |
| 22. _____ | An explosion occurring at the tip accompanied by gasses burning back into the hoses and regulator (shrill squealing or hissing). | G. Forehand Welding |
| 23. _____ | The bonding of two metal objects by adhesion with a minimum of alloy. | H. Lead Angle |
| 24. _____ | The combining of oxygen with any other substance. | I. Oxyacetylene Cutting |
| 25. _____ | The rapid oxidation or burning of metal at high temperatures. | J. Brazing |

Multiple Choice

26. _____ Which is not a true description of oxygen?
- Oxygen is a colorless gas
 - Oxygen has no smell or taste.
 - Oxygen is flammable
 - Oxygen readily supports combustion

27. _____ Which is NOT a true description of acetylene?
- Acetylene is a colorless gas.
 - Acetylene has no smell.
 - Acetylene is flammable
 - Acetylene is explosive when compressed above 15 psi.
28. _____ Which of the following statements about oxyacetylene cutting applications is not true?
- It can be applied to all carbon steels up to 0.25% carbon.
 - It can also be applied to higher carbon steels, but only with some difficulty.
 - It can be applied to copper, aluminum, or high-nickel alloys.
29. _____ Which range does an oxygen cylinder gauge read?
- 0 – 30 psi
 - 0 – 200 psi
 - 0 – 400 psi
 - 0 – 4000 psi
30. _____ Which range does an acetylene working gauge read?
- 0 – 30 psi
 - 0 – 200 psi
 - 0 – 400 psi
 - 0 – 4000 psi
31. _____ Which range does an oxygen working gauge read
- 0 – 30 psi
 - 0 – 200 psi
 - 0 – 400 psi
 - 0 – 4000 psi
32. _____ Which range does an acetylene cylinder gauge read
- 0 – 30 psi
 - 0 – 200 psi
 - 0 – 400 psi
 - 0 – 4000 psi
33. _____ Which is the best description of a carbonizing flame?
- Excess amount of oxygen.
 - Excess amount of acetylene.
 - Equal amounts of oxygen and acetylene.

Answer Sheet

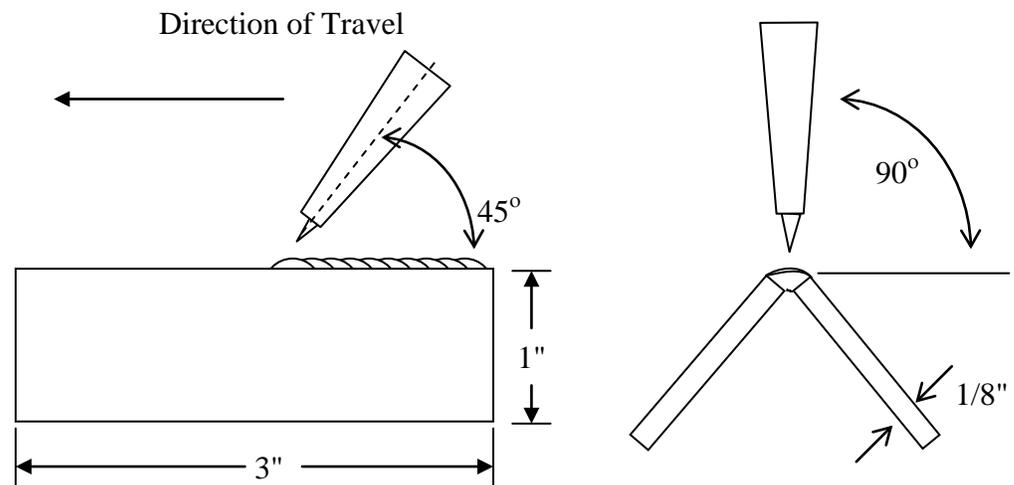
1. T
2. F
3. T
4. F
5. T
6. T
7. T
8. F
9. F
10. T
11. T
12. T
13. T
14. T
15. F

16. E
17. G
18. F
19. A
20. H
21. C
22. D
23. J
24. B
25. I

26. C
27. B
28. C
29. D
30. A
31. B
32. C
33. B

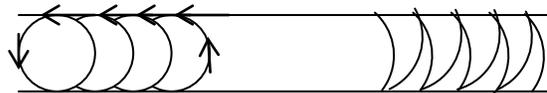
Fusion Weld Without Rod

1. Suggested tip, use manufactures' chart (#0 for Victor).
2. Use assigned metal.
3. Set gauges, see chart (victor equipment, 5 psi oxy and 5 psi acet).
4. Maintain about 1/8" between cone & puddle.
5. Maintain 45° travel angle, 90° work angle.
6. Tip should point straight with direction of welding.



Bead: 3/8" wide, full length of metal

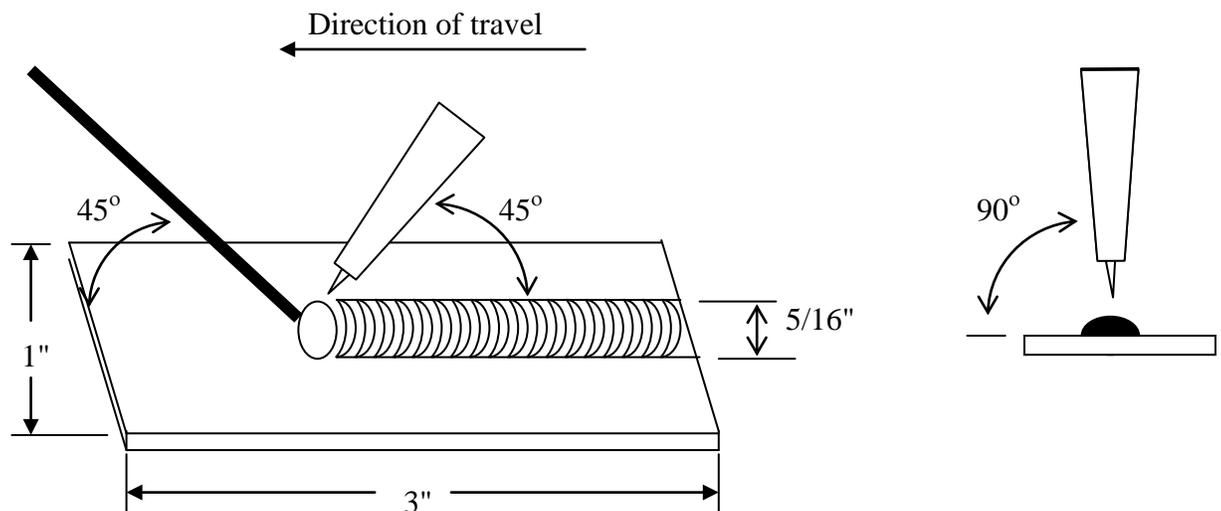
7. Use circular or semi-circular motion.



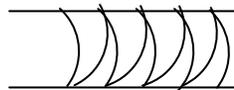
8. Right handed persons start on the right side – work towards left
9. Methods to control heat.
 - A. Change tip size – for more heat , larger tip
 - B. Change flame angle – for more heat, straighter up and down
 - C. Change speed of travel – for more heat, slow down
 - D. Change flame to puddle distance – for more heat, get closer

Fusion Bead Weld, With Rod

1. Suggested tip, use manufactures' chart (#0 or #1 for Victor).
2. Use two pieces of the assigned metal.
3. Set gauges, see chart (for Victor equipment, 5 psi oxy and 5 psi acet).
4. Maintain about 1/8" between cone & puddle.
5. Maintain 45° torch angle, 90° work angle.
6. Use filler rod approximately same diameter as metal thickness.
7. Maintain a 45° rod angle and use slight up and down motion into the puddle.
8. Tip should point straight in direction of welding.



9. Use semi-circular motion with the torch



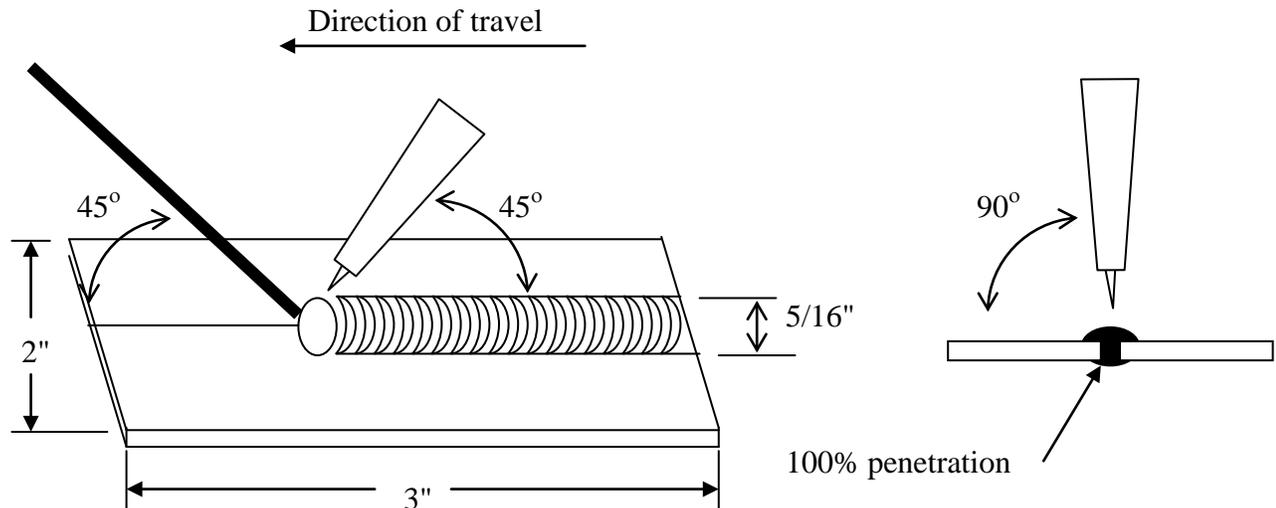
- 10 Right handed persons start on the right side – work towards left

- 11 Methods to control heat.

- A. Change tip size – for less heat, use smaller tip
- B. Change flame angle – for less heat, use more angle
- C. Change speed of travel – for less heat, speed up
- D. Change flame to puddle distance – for less heat, get farther away

Fusion Butt Weld, With Rod

1. Suggested tip, use manufactures chart (#0 or #1 for Victor).
2. Use assigned metal.
3. Set gauges, see chart (for Victor equipment, 5 psi oxy and 5 psi acet).
4. Maintain about 1/8" between cone & puddle.
5. Maintain 45° torch angle, 90° work angle.
6. Start with a 1/16" gap on the starting end and 1/8" on the finishing end.
7. Use filler rod approximately same diameter as metal thickness.
8. Maintain a 45° rod angle and use slight up and down motion into the puddle, keeping the bead equal on both sides of the joint.
9. Tip should point straight in direction of welding.



10. Use semi-circular motion with the torch.

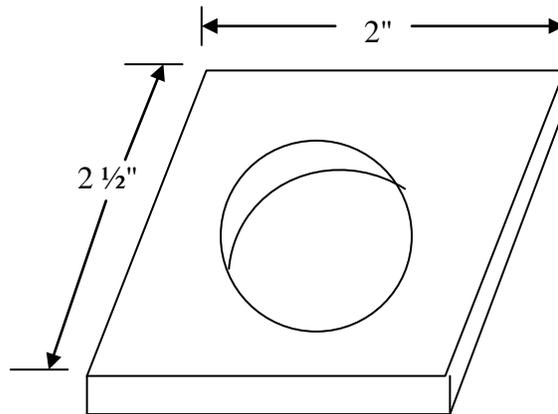


11. Right handed persons start on the right side – work towards left
12. Methods to control heat.
 - A. Change tip size.
 - B. Change flame angle.
 - C. Change speed of travel
 - D. Change flame to puddle distance

Oxyacetylene Cutting

1. Choose proper tip from chart, clean tip frequently.
2. Set oxy-acet pressure according to chart.
3. Light torch – turn up acet until smoke clears or until flame leaves tip then turn down until the flame is back on the tip.
4. Adjust to neutral flame, depress oxy-lever and adjust again.
5. Torch should produce cutting lance about 6" long.
6. Preheat, when edge of metal turns red, gently depress cutting lever to full-on position.

Use 3/8" to 5/8" steel



7. Move as rapidly and steadily as possible without losing cut; observe spark steam – sparks go straight down with proper speed.
8. Torch tip should be held vertical to plate with tips of preheat flames 1/8" above metal.
9. When making practice cuts, cool between each cut.

SPECS:

1. Do not grind the end to be graded.
2. Use chipping hammer and wire brush.
3. Cut hole in the center _____ inch (es) in diameter.
4. Pipe must slide thru hole easily.
5. Cuts to be straight & square with side.
6. To have no slag or top edge melting.

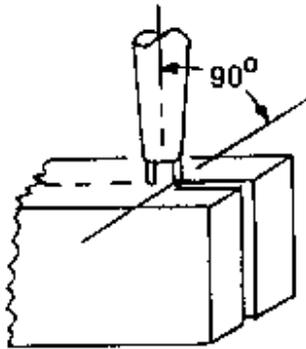
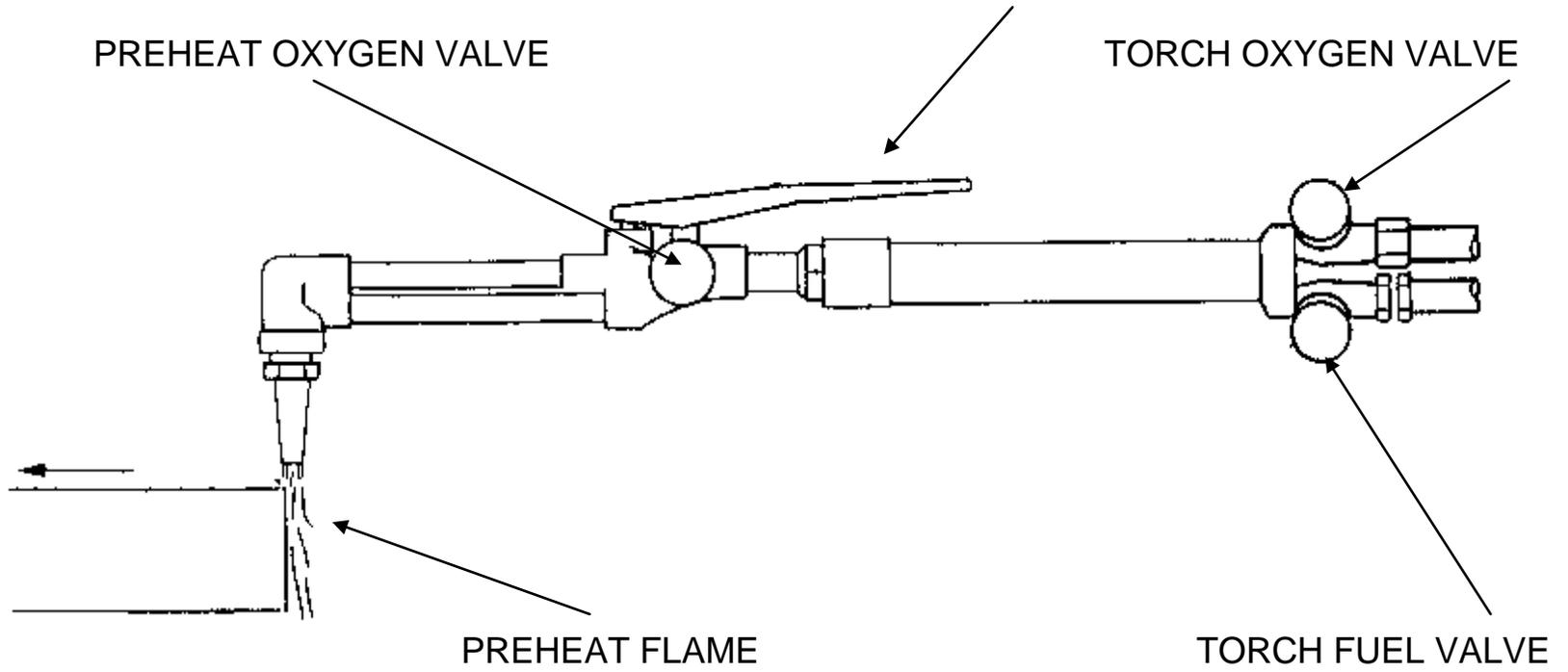
130W-33

OXYACETYLENE CUTTING TORCH

CUTTING OXYGEN VALVE LEVER

PREHEAT OXYGEN VALVE

TORCH OXYGEN VALVE



130X-1

INTRODUCTION TO ARC WELDING

AG 130-X

UNIT OBJECTIVE

After completion of this unit, students will be able to operate an arc welder safely, understand the AWS electrode classification, and demonstrate different arc welding skills. This knowledge will be demonstrated by completion of assignment sheets and a unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES AND COMPETENCIES

After completion of this unit, the student should be able to:

1. Pass a safety test and demonstrate proper use of arc welding equipment.
2. Strike and maintain an arc correctly.
3. Be familiar with the American Welding Society (AWS) classification for electrodes.
4. Be familiar with the American Welding Society (AWS) basic blueprint reading for welds
5. Identify four basic weld joints and demonstrate the application of each in the flat position, using AC and DC equipment.

ARC WELDING EQUIPMENT AND SAFETY

A. Introduction to Arc Welding

1. An arc welding machine joins two metals together by generating an electric arc between a coated metal electrode and a base metal. The heat of the electric arc melts the metal which mixes with the molten deposits of the coated electrode. The coating of the electrode produces a gas which shields the weld from the atmosphere and helps to maintain the weld shape. This coating is later removed in the form of slag. The slag coating over the weld insulates the hot weld from contaminants in the air during cooling.

B. Equipment Used in Arc Welding

1. Power Supply

- a. The power supply of the arc welding apparatus must maintain a relatively constant current with only a slight change in voltage.
- b. Varying voltage and current will result in an uneven arc that creates splatters and uneven welds.
- c. There are three main types of power supplies.

1) Generators

- a) Generator powered arc welding machines run on direct current.
- b) These welding machines are commonly used in industry and are noisy, expensive to purchase, and costly to operate.

2) Transformers

- a) These machines are generally the cheapest to purchase and run on an alternating current.

3) Rectifiers

- a) The rectifier is a more versatile arc welding power supply that can be run on either direct or alternating current.

2. Ground Clamp

- a. The ground clamp completes the full electrical circuit so that enough heat will be available for the welding job.
- b. The ground clamp must be securely fastened to the metal being welded or to an adjoining workbench or piece of metal.

3. Electrode Holder (or Stinger)

- a. The stinger receives the amperage and directs it through the electrode to form the arc.
- b. The electrode holder should be well insulated, have a strong spring to firmly grasp the electrode, and a release lever to exchange the electrodes easily.

4. Cables

- a. The cables allow both the ground clamp and the stinger to be mobile.
- b. The cables should also be well insulated and protected from the heat during welding.

5. Electrode

- a. The electrode consists of an internal metal core and an outer coating called flux which shields the weld. The core melts into the molten base metal to produce the metal bond.
- b. There are several types and sizes of electrodes. Each will be discussed in detail in the next lesson.

C. Protective clothing must be worn at all times when welding. The heat created during arc welding creates flying molten sparks and ultraviolet and infrared rays that can burn the skin.

1. Leather Gloves

- a. Gloves protect the hands from burns during welding.
- b. The gloves should be made of thick leather and have long cuffs to protect the wrist and prevent sparks from falling into them.

2. Leather or Cotton Sleeves

- a. A NONFLAMMABLE material should be worn on the arms to protect from burns due to sparks and intense heat.

3. Body Protection

- a. Either a leather apron or coveralls or workshirt made of a flame retardant material will protect the body during arc welding.
- b. All protective clothing should fit properly and be free of openings or rips into which a spark might enter or the intense heat might penetrate.

4. Footwear.

- a. Leather boots should be worn while arc welding.
- b. Never wear open-toed shoes while working with hot metal or a welding apparatus.

D. Arc Welding Helmets and Shields - The brilliant light given off by the electric arc produces invisible ultraviolet and infrared rays which can severely burn the eyes and skin. **NEVER LOOK AT THE ARC WITH THE NAKED EYE.** Helmets and shields are equipped with special filtered lenses that reduce the intensity of the light and prevent the ultraviolet and infrared rays from reaching the eyes.

1. The welding helmet is designed specifically for the purpose of arc welding.
 - a. The welding helmet fits on the head using a plastic adjustable headband.
 - b. The helmet leaves both hands free for working and positioning materials.
 - c. Many helmets have clear lenses under the filtered lenses that can be used when chipping slag.
2. The hand shield is used for observing.
 - a. It is **NOT** advisable to use the hand shield when welding since one hand must be used to hold the shield in place.
3. The protective lenses come in different shades depending on the type of welding to be done. Different types of welding use different amounts of voltage and current which determine the intensity of the light and the amount of ultraviolet and infrared rays produced. Spot welding requires the fewest amperes and thus requires the least amount of shading in the lens. Arc welding machines require from less than 30 to over 400 amperes. Lens shades range from number 5 (which provides the least amount of protection) to shade 14 (which provides the most protection).

130X-5

- a. Shade 5 is used for light spot welding.
 - b. Shades 6 and 7 are suitable for welding with up to 30 amperes.
 - c. Shade 8 is for welding with 30-75 amperes.
 - d. Shade 10 can be used when welding with 75-200 amperes.
 - e. Shade 12 is used when welding with 200-400 amperes.
 - f. Shade 14 is required when welding with over 400 amperes.
4. Cover glasses are clear lenses that are used to stop flying slag or metal, thus protecting the filter lenses. There are 3 different types of cover glass currently available.
- a. Clear, unbreakable plastic is the cheapest and lasts the longest.
 - b. Chemically treated glass is used to reduce pitting but it can be expensive.
 - c. Plain glass is very susceptible to breaking, pitting, and splatter sticks and is NOT recommended.
5. Filter lenses must be changed if a crack or chip occurs in order to prevent ultraviolet and infrared rays from reaching the eyes. The shades of the lenses must also be changed. If the shade is too dark, the worker will be unable to see the work that is being performed. If the shade is too light, proper eye protection is not achieved. Many welding helmets have interchangeable lenses. The lens changing procedure is as follows:
- a. Remove the lift-up mechanism on the helmet or the lens frame lock.
 - b. Slide the old filter lens out and insert the new one.
 - c. Reinsert the lift-up mechanism or the lens frame lock.
 - d. Put the helmet on and search for light leaks. If leaks are present, the lens must be readjusted.

E. Additional Welding Equipment

1. Goggles - Goggles must be worn when chipping slag if a shell lens is not provided in the helmet. **NEVER CHIP SLAG WITHOUT PROTECTIVE EYEWEAR.**
2. Tongs - The heat of the arc will heat all of the metal being welded. Always use tongs to carry or maneuver the metal stock.
3. Slag Hammer or Chipping Hammer - The slag hammer is used to remove slag from the weld for proper cooling.
4. Wire Brush - If a second pass is to be made with the arc, the wire brush must be used to remove all slag fragments from the welding area. If not removed, the weld will not be solid and residual stresses will result.

C. Safety in Arc Welding

SAFETY IN ARC WELDING

When arc welding, observe the following general safety practices.

1. Wear gloves and eye and face protection. The welder and all observers must wear welding helmets with a No. 10 or 12 filter lens. A welding cap or helmet with a hard hat is also recommended for head protection. When chipping slag or cleaning welds, wear a clear face shield or flip-up liftplate on the helmet.
2. Avoid electrical shock. Make certain that the electrode holder and all electrical connections and cables are properly insulated. Check to see that the welder is properly grounded. Do not dip the electrode holder in water to cool it because this practice may result in electrical shock.
3. Protect others. For small and practice welding jobs, work in a partitioned area to protect others from harmful rays. When prepared to strike the arc, inform all bystanders to cover their eyes.
4. Never weld in a damp area. Stand on a dry board or rubber mat if the floor or ground is damp or wet.
5. Never wear synthetic fiber clothing. Synthetic fibers are highly flammable. Wearing clothing made from wool or cotton is more satisfactory for welding because of their relatively high flash points.
6. Protect welding cables. Keep the cables from coming in contact with hot metal and sharp edges. Do not drive over cables. When welding, avoid wrapping electrode cables around your body.
7. Secure work. Use a welding table with a positioner to hold welds securely in place. Clamps and vises can be used to hold odd-shaped work or field work. Securing work will also prevent injury from accidental dropping of metal on your feet or body.
8. Dispose of electrode stubs properly. Keep a container in the work area in which to deposit electrode stubs. This prevents burns to shoes or falls due to stubs rolling underfoot.
9. Prevent burns. Never allow the hot electrode or electrode holder to touch bare skin. Avoid letting the electrode touch a grounded cable. Remove hot metal from the work area when you are finished welding to prevent burns to others.
10. Do not let the electrode stick. If the electrode sticks, cut off the switch, allow the electrode to cool, and then break it loose with your gloved hand.
11. Use both hands. To reduce fatigue, use both hands for welding.
12. Handle hot metal with pliers or tongs. Submerge hot metal completely in water to prevent steam burns.

13. Weld in a well-ventilated area. The fumes from lead, zinc, cadmium, and beryllium are toxic and may cause sickness or death.
14. Do not carry matches or lighters, and do not allow bystanders to smoke. Before welding, make sure the welding area is free of other flammables (gas, grease, etc.).

* Reprinted by permission of Interstate Publishers, Inc., from MODERN AGRICULTURAL MECHANICS, 2nd ed., by Stanley R. Burke and T. J. Wakeman. Copyright 1992 by Interstate Publishers, Inc.

ACTIVITY:

1. Practice changing lenses and head gear in arc welding helmets.
2. Practice identifying and handling arc welding equipment, making sure that all safety procedures are followed and that suitable clothing is being worn.

STRIKING AND MAINTAINING AN ARC

A. Setting, Checking, and Adjusting the Equipment

1. Equipment adjustment for proper amperage is vital for arc establishment.
 - a. To start the welding operation make sure that the electrode holder and ground clamps are clean and in good condition. Inspect the cable connection to make sure they are tight and that no exposed wires are present.
 - b. The welding bench should be clean and dry.
 - c. The ground clamp should be attached to the welding bench in a secure manner.
 - d. If using D.C. polarity, it is important that the machine is set for straight or reversed current
 - e. The next step is to select the proper amperage. Tentatively determine the recommended current setting for the type and size of electrode to be used; make the final adjustment after the actual welding operation has been started. The electrode selection chart gives both a low and a high setting choice. A current value midway between the two limits is recommended. The following electrodes are recommended for this exercise: E6010, E6011, E6012, E6013 or E7014.

130X-8

NOTE: Some instructors like to use E-6013 and E-7014 rods because they strike and hold an arc easily and beginning welders build confidence. However, others feel that changing back to a E-6011 type rod is more difficult and they prefer to start with a fast-freeze rod of E-6011 type. It is also suggested that you use 1/8" or 5/32" electrodes for this exercise (see electrode selection chart in the addendum).

B. Striking an arc

1. Select a plate or coupon of steel 1/4" thick, 3" to 5" wide, and 6" to 10" long.
 - a. There are two methods that can be used to start or strike the arc: a tapping or a scratching motion. The tapping method is the one that experienced welders use, whereas the scratching motion method is generally easier for the beginner.
 - 1) The scratching motion method requires that the electrode be brought down at an angle to the plate very similar to scratching a match. When the arc is started (flashes) the electrode must be quickly raised so that it will not stick to the base metal.
 - 2) The tapping method requires that the rod be held directly above the work. The rod is brought down and touches on the base metal. As the arc strikes, the rod must be quickly brought up to approximately the thickness of the electrode or the rod will stick to the base metal.
 - 3) If the rod sticks to the base metal, the current flow will cause the rod to become very hot. To remove a stuck electrode from the work, use a quick twisting or striking motion of the electrode holder. If this does not break the electrode loose, remove the electrode holder from the grip end of the electrode. Since this electrode is red hot, use pliers to twist it loose.
 - b. Practice striking and stopping the arc until this action can be completed quickly and easily.
 - 1) A good practice coupon can be laid out in a grid pattern with center punch mark 1/2" apart. Practice starting the arc on each of these marks.
2. Practice running beads after the skill of striking and maintaining an arc has been mastered.

130X-9

- a. Stringer beads are an excellent bead for beginning welders to make. The beads will not be consistent but should improve with practice.
 - b. The beginning welder can practice with different electrode settings, arc lengths, electrode angles, and speeds until a smooth, strong weld is produced.
 - 1) Welding done with proper amperage, voltage, and speed displays
 - a) Good penetration
 - b) No undercut or overlay
 - c) Smooth appearance
 - 2) If the arc is too long, there is:
 - a) Poor penetration, overlap, spatter
 - b) Leaves weld puddle exposed to oxidizing air
 - 3) If the welding current setting is too high, there is:
 - a) Spatter and undercutting
 - b) A deep crater
 - 4) If the welding current setting is too low, there is:
 - a) Poor penetration with high narrow bead
 - b) Not enough current to fuse weld to metal
 - 5) If the welding speed too fast, there is:
 - a) Irregular bead with skips
 - 6) If the welding speed too slow, there is:
 - a) Bead too high, somewhat irregular and porous
 - b) Builds up too much metal and metal stays melted too long
3. After mastery of the stringer bead, practice oscillation, which entails keeping the tip of the rod weaving back and forth across the molten weld pool.

130X-10

- a. The weaving motion of the electrode keeps the molten metal pool agitated; this helps float the slag and impurities to the top so they can be removed by chipping and brushing and it also helps to reduce porosity within the weld bead area.
 - b. The weave bead also can be used to give a wide coverage (cover pass) for the weld joint.
 - c. The weave bead will improve penetration and thicken pieces of weld plate.
 - d. The basic weave bead is a crescent-shaped zigzag.
 - 1) Hesitate at sides to prevent undercutting and to allow the bead to build.
 - 2) Be sure to bond the weave to the material on each side.
4. There are various other welding patterns, for example, whipping motion, semicircular motion, circular motion, V-shaped motion, back and forth or N-shaped motion, U-shaped motion, figure-8 motion, and rotary motion.
5. Metal Preparation
- a. Cut a plate approximately 4" X 5" X 1/2"
 - b. Brush and clean plate
 - c. Mark 4 lines 1/2" apart down the 5" length
 - d. Run a stringer bead down each line with 1/8" rod
 - e. Chip and clean stringer beads
6. Weaving Exercise
- a. Weave beads between stringers to cover plate with smooth weld
 - b. Fuse the weave into the stringers
 - c. Chip, clean, and evaluate work

ACTIVITY:

1. Strike and maintain an arc by building up a small boss on each center punch mark on coupon
2. Explain what happens when an arc is being maintained.
3. Start and restart the electrode at different places on the coupon.
4. Run and evaluate stringer bead for correctness.
5. Run and evaluate weave beads.

AWS CLASSIFICATION SYSTEM FOR ELECTRODES

A. What are electrodes and how are they selected for various welding applications?

1. Shielded electrodes are thin metal rods having approximately the same composition as the metal to be welded. They are coated with a wide variety of types of flux.
2. Electrodes are designed not only to weld different metals but also to use AC, DC reverse, or DC straight polarity electric current.
3. Electrodes come in various diameters; the larger the diameter the higher the amperage required to properly use the electrode.
4. It is very important that the appropriate electrode be selected for a given welding operation. Poor electrode selection will cause difficulty in completing a good welding job.
5. Electrodes are classified into five main groups:
 - a. Mild steel
 - b. High-carbon steel
 - c. Special alloy steel
 - d. Cast iron
 - e. Non-ferrous

B. The American Welding Society (AWS) has developed the following electrode classification system:

1. What does the classification E-7018 on an electrode mean? Reading from right to left.
 - a. The right-hand digit (8) indicates the special characteristics of the electrode, such as type and general content of the coating, weld quality, amount of penetration, and the type of arc or electrical current. The right-hand-digit may be any number between 0 and 8. It is important to note that the right-hand digit cannot be considered individually but must be considered in conjunction with the second digit from the right in order to identify both the polarity and position of the electrode.
 - b. The second digit from the right (1) indicates the positions the welding electrode can be used. This digit may be any number between 1 and 4.
 - 1) 1 indicates the electrode can be used in all positions; flat, horizontal, vertical, and overhead.
 - 2) 2 indicates the electrode can be used in flat or horizontal positions.

130X-12

- 3) 3 indicates the electrode should only be used in the flat position.
- 4) 4 indicates the electrode can be used for vertical down welds only.

c. The two or three digits to the left (70) indicate the tensile strength in thousands of pounds per square inch (i.e., 70 means 70,000 psi).

C. Selecting the correct Electrode

1. The electrode should produce a weld metal with approximately the same metallurgical properties as the parent metal. A top quality weld should be as strong as the parent material.
2. In selecting the best electrode for a particular welding situation, the aim is to choose one that will provide good arc stability, fast deposition, maximum weld strength, minimum splatter, easy slag removal, and a smooth weld bead. To achieve these characteristics from an electrode, the following factors should be considered:
 - a. Electrode Diameter – Generally, an electrode with the diameter larger than the thickness of the base material should not be used. If this is done, welding must be done at a very high rate of speed and this requires considerable skill in order to obtain a sound weld. When making a vertical or overhead weld, a fast freeze type electrode with the diameter of 1/8” would normally be used. Regardless of the base metal size, an electrode diameter of 3/16” is the maximum size used. Electrode diameter is also determined by the joint design such as a joint with narrow gap or V-groove base metal plates. When this is a factor, use a small diameter electrode to do the root pass or the first weld bead.
 - b. Joint Design – This is another important factor to consider when choosing an electrode.
 - 1) When welding a joint that is not beveled at the proper angle to allow easy penetration, consider using a deep penetrating, fast freeze electrode, for example, E-6010 or E-6011. The opposite of this situation would be an open or poorly fit joint where a good choice of electrode is E-6012 or E-6013.
 - c. Welding Position – The welding position to be used during the deposition of the weld metal is a very important factor when selecting an electrode.

- d. Type of Welding Current – This is another factor to consider when choosing an electrode. Some electrodes are designed for AC and DC straight or DC reverse polarity while others are designed to function properly using either AC or DC current. Information regarding current is generally written on the outside of the package and does not have to be figured from the AWS classification number.

ACTIVITY:

1. Select six different arc electrodes and outline in writing each of their characteristics.
2. Weld a bead with each of the six arc electrodes and describe in writing how each electrode reacts during the welding process.
3. Weld various beads using DC straight, DC reverse, and AC type currents.

FOUR BASIC WELDS

A. Welding a Bead

1. A weld is known as a bead, made by one pass of an electrode.
2. Welding a bead is the first step after striking an arc and towards making other types of welds.
3. Stopping and restarting a bead in the middle of a weld should be practiced. Due to the fact when you run out of an electrode you will need to restart with a new one.
4. Set welding amperage to desired setting (depending on the electrode and the thickness of metal used.)
5. Keep arc length between 1/16" – 1/8", listen to it (sounds like frying bacon) and keep it constant.
6. Angle the electrode 15° – 20° from vertical towards the direction of travel. At the same time keep the side to side angle at 90°.
7. Speed of travel, watch the width of the puddle and keep it constant.

B. Butt Weld

1. The butt joint is one of the most frequently used weld joints.
 - a. A butt joint consists of placing the edges of two pieces of metal together.

2. The butt joint is used when structural pieces have a flat surfaces, for example, tanks or flat decks, and when laminating pieces for machine parts.
3. There are three types of but joints: closed, open, and when laminating pieces for machine parts.
4. The closed butt should be used only if the material to be welded does not exceed 1/8" to 3/16" in thickness.
5. When using the open butt, the joints are spaced 3/32" to 1/8" apart.
6. When the material to be welded exceeds 3/16" in thickness, the butt joint should be beveled. There are three types of bevel or V joint designs:
 - a. In a feather edge, the material is 1/8" to 3/16" thick, the bevel is 60 degrees and the bottom edges of the material are placed together.
 - b. The shoulder edge is used for materials 1/4" or more thick; 1/16" to 1/8" of the bottom of the material is not beveled and a gap of 1/8" is allowed for the root pass.
 - c. The double V is used for material over 3/8" thick. This V joint has a 60 degree bevel; however, a 3/32" to 1/8" face is left in the lower 1/3 of the weld joint. This root face is generally spaced 1/8" apart for proper root pass operation.
7. If the bevel on any groove joint is greater than 60 degrees, it is difficult to limit and control the amount of contraction when the metal cools.
8. A backup strip should be used in an open butt joint in order to prevent excessive burn-through.
9. A round stock weld is a variation of the butt joint weld.
 - a. In order to weld rods or round solid shaft material, both ends of the stock must first be beveled, leaving a shoulder in the center. The edges should be ground so they have the same angle

C. Pad Welding

1. A pad weld is used to build up metal surfaces after it has been worn down.
2. Pad welding can be done on flat or round surfaces.
3. Pad welding consists of depositing several layers of beads.
 - a. Welding a bead to cover half of the previous bead.
 - b. Welding beads one over the top of another

4. Angle the electrode 15° – 20° from vertical towards the direction of travel. At the same time keep the side to side angle at 90° for the first pass. For the second, third, etc. hold the electrode 10° – 15° from vertical.

D. Fillet Weld (Tee Joint)

1. The tee joint is formed by placing one plate at a 90 degree angle to another to form a letter T. A tee joint is a Fillet-type weld.
 - a. The tee joint is weak and should not be used if heavy pressure will be applied from the opposite direction of the welded joint.
 - b. There are several types of fillet joints. The basic fillet welds for tee joints are classified as square, single bevel, double bevel, single J and double J.
 - 1) The square tee is used where the material can be welded on one or more side. Considerable weld metal is required for maximum strength.
 - 2) The single bevel tee is used on material that is less than 1/2" thick. This joint will withstand more severe loading than the square tee, where welding can be done from one side only.
 - 3) The double bevel tee is used where heavy loads are applied in all directions and where welding can be done on both sides.
 - 4) The single J joint is used on material 1 1/2" and thicker and can be welded from both sides.
 - c. To start a practice fillet, use 3/16" to 1/4" thick material. Set the vertical plate on the middle of the flat plate and tack weld each end. Then start the main weld. On material of this thickness, a single pass (which is one layer of a weld bead) should be sufficient.
 - d. The angle of electrode is very important. The best results are obtained by holding the electrode at 45 degrees between the vertical bottom flat plate with the tip pointed toward the weld area. The direction of travel will have a 15° - 25° angle in the direction of travel. This first single pass bead should be a 1/4" fillet.

ACTIVITY:

1. Prepare and weld each of the four types of welds.
2. Design and build a project utilizing at least three different types of welds.

References:

Burke, Stanley R., & Wakeman, T. J. (1990). MODERN AGRICULTURAL MECHANICS (2nd ed.). Danville, IL: Interstate Publishers.

Cooper, Elmer L. (1997). AGRICULTURAL MECHANICS: FUNDAMENTALS AND APPLICATIONS, 3rd EDITION. Albany, NY: Delmar Publishers.

Special Material and Equipment:

Arc welding helmet, leather gloves, aprons, coveralls, strikers, safety test, slag hammer, safety goggles

Resources:

Deere & Company. (1987). WELDING (6th ed.) (Fundamentals of Service (FOS) Series). Available from: John Deere Technical Services, Dept. F, John Deere Road, Moline, IL 61265 (Available in Spanish)

Giachino, Joseph W., & Weeks, William (1976). WELDING SKILLS AND PRACTICES (5th ed.). Available from: American Technical Society, Chicago, IL 60637

Hobart Brothers Company. (1978). TECHNICAL GUIDE FOR SHIELDED METAL ARC WELDING. Available from: Hobart Brothers Company, Troy, OH 45373

Name _____

Date _____

Score _____

UNIT EXAM, ARC WELDING

Multiple Choice, circle the letter that best represents the correct answer.

Short answer

1. Which of the following is not a type of welding power supply?
 - a. Rectifier
 - b. Transformer
 - c. Alternator
 - d. Generator

2. What is the purpose of the ground?

3. The flux of an electrode
 - a. forms a gas
 - b. creates slag
 - c. forms a shield for the weld
 - d. all of the above

4. The best material to use for protection clothing , footwear, and gloves is
 - a. nylon
 - b. leather
 - c. polypropylene
 - d. dacron

5. The darkest and most protective lens available for welding purposes is
 - a. Shade 5
 - b. Shade 7
 - c. Shade 10
 - d. Shade 20

6. The ground clamp should be attached to
 - a. a non-conductive block of wood
 - b. the project or worktable
 - c. a properly grounded bolt mounted in the floor
 - d. the electrode

7. A weld with the proper amperage, voltage, and speed displays
 - a. good penetration
 - b. no undercut or overlay
 - c. a smooth appearance
 - d. all of the above

8. When the voltage setting is too low, the weld
 - a. spatters and undercuts
 - b. digs a deep crater
 - c. leaves the weld puddle exposed to oxidizing air
 - d. provides poor penetration with a high, narrow bead

9. What is the tensile strength of an electrode marked E6013

10. What does the E represent on an electrode marked E6011

11. What does the third and fourth digits represent on an electrode marked E7018

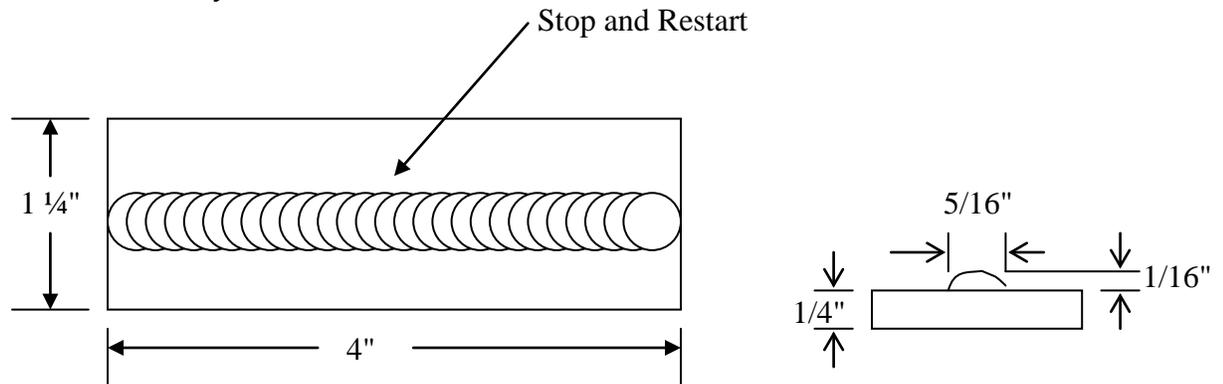
130X-19

Answer Sheet

1. C
2. Completes the full electrical circuit
3. D
4. B
5. C
6. B
7. D
8. D
9. 60,000lbs of tensile strength per inch of weld.
10. Electrode
11. The third digit indicates the position the rod can be used in and the fourth indicates the characteristics of that rod, 1 means all positions and the 8 means low hydrogen.

130X-20
Arc Welding, Bead

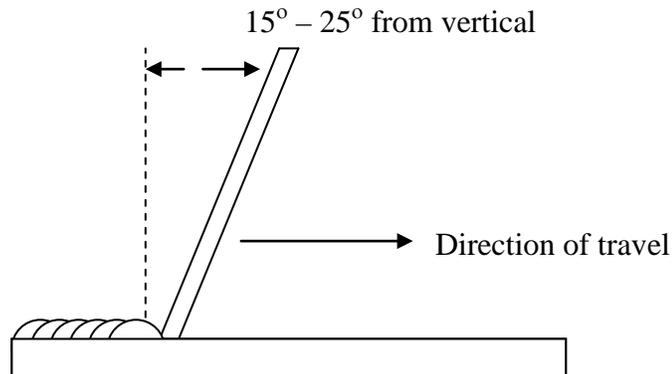
1. Use 1/8" E6013 electrode.
2. Use 1/4" x 1 1/4" 4" metal.
3. Stop completely and restart in middle of weld.
4. Fill in crater at the end of bead.
5. Clean the weld with wire brush.
6. Weld one side only.



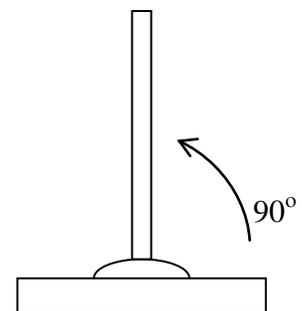
Variables that influence the bead:

1. AMPERAGE Use middle range from chart & adjust from there.
2. ARC LENGTH Usually 1/16" – 1/8" Listen to it (frying bacon)
Keep it constant.

3. ANGLE OF ELECTRODE



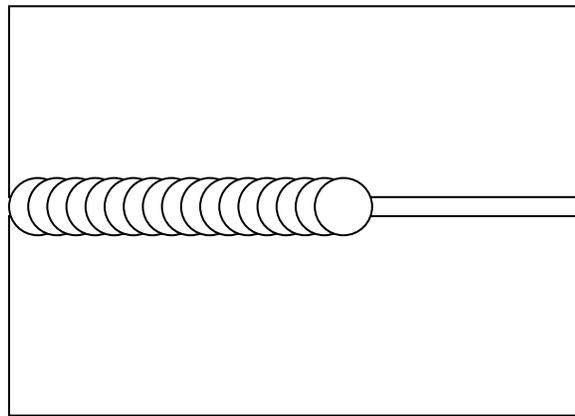
END VIEW



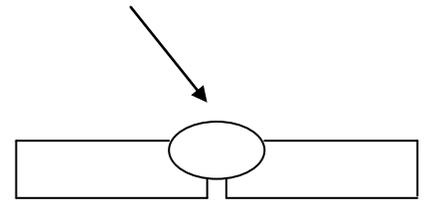
4. SPEED OF TRAVEL Watch the width of puddle – keep it constant
5. ELECTRODE

Arc Welding, Butt Weld

1. Use 1/8" E6013 electrode.
2. Use two pieces of 1/4" x 1 1/4" 4" metal.
3. Bead with equal length on both sides of the joint.
4. Fill in crater at the end of bead.
5. Clean the weld with wire brush.
6. Weld one side only.



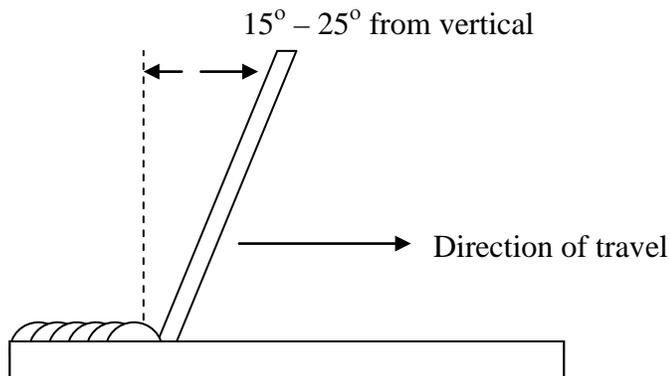
Equal length on both sides



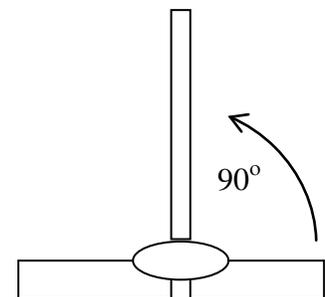
1. AMPERAGE Use middle range from chart & adjust from there.

2. ARC LENGTH Usually 1/16" – 1/8" Listen to it (frying bacon)
Keep it constant.

3. ANGLE OF ELECTRODE



END VIEW



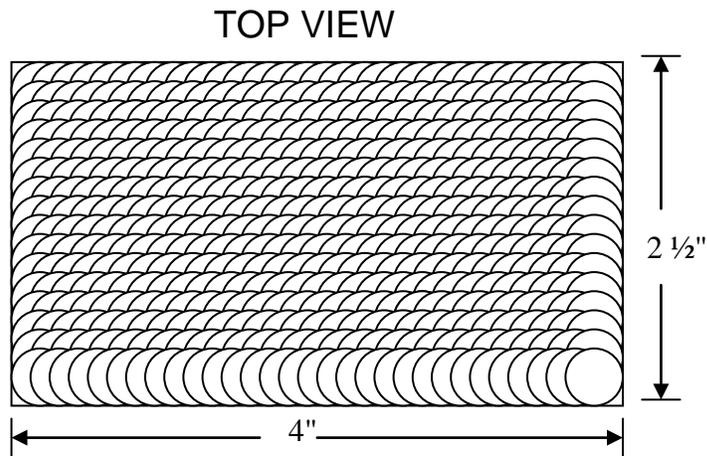
4. SPEED OF TRAVEL Watch the width of puddle – keep it constant
and even on both sides

5. ELECTRODE

130X-22

Arc Welding, Pad Weld

1. Use 5/32 E6013
2. Use 4" x 2 1/2" x 1/2" metal
3. Cover entire surface of the plate with overlapping welds.
4. Cover half of the previous bead.
5. Cool between beads only until red color is gone



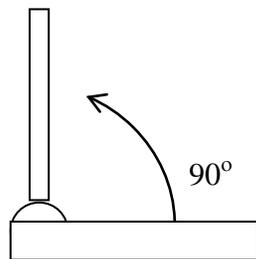
END VIEW



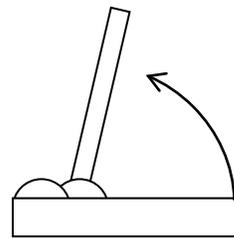
WRONG



RIGHT



First Pass



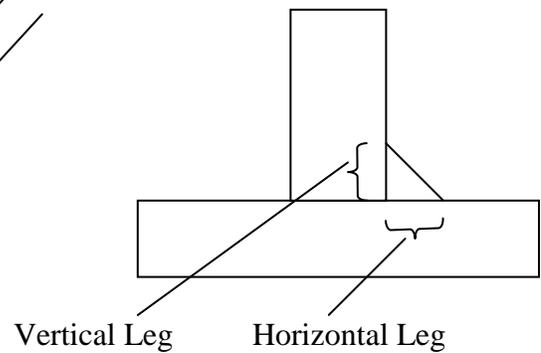
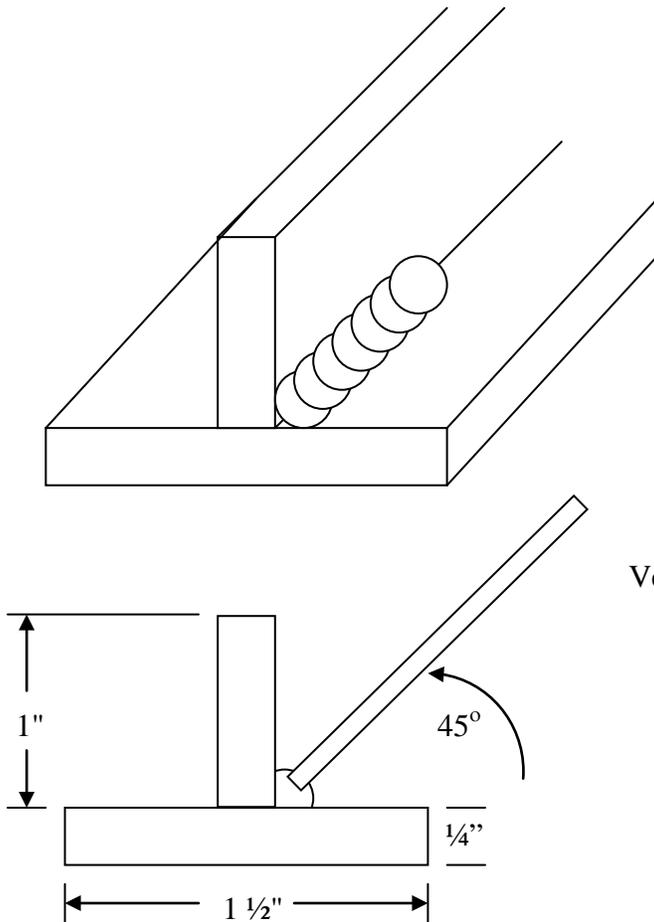
Second Pass, etc.

10° – 15° from vertical

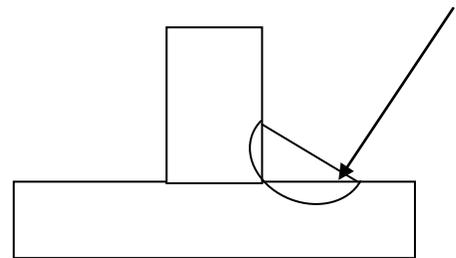
6. Finished surface to be as flat as possible.

Arc Welding, Horizontal Fillet

1. Use 1/8" E6013 electrode.
2. Use 1/4" x 1 1/2" x 4" metal for the base.
3. Use 1/4" x 1" x 4" metal for the upright.
4. Use a short arc length.
5. Hold the electrode at a 45° angle from the base plate.
6. Hold the electrode at a 15° – 25° angle in the direction of travel.
7. Horizontal and vertical legs need to be **equal**.



Unequal Legs, Unequal Penetration

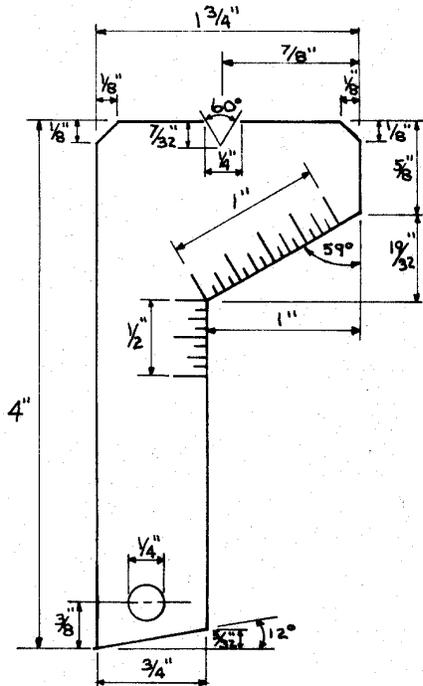


Undercutting Caused by:

1. Too long of an arc.
2. Electrode too straight up and down.
3. Too much amperage.
4. Using motion.
5. Too much lead angle.

TOOL SHARPENING GAGE

ORDER NO. 502



Construction procedure:

1. Square one corner of aluminum or brass stock.
2. Measure and scribe outline on stock with awl.
3. Mark graduations with awl.
4. Cut out tool gage with hacksaw. (Use protective blocks on each side when cutting in vise.)
5. Dress to the lines with file, bevel corners.
6. Use three-square file to cut chisel vee.
7. Polish with steel wool.
8. Submit to instructor for evaluation.
9. Drill size holes 1/4", 3/16", 1/8", and 1/6" may be drilled in the body of the gage.

Questions:

1. Why is aluminum easier to work than brass?
2. Why is it important to square or make a corner 90°?
3. Which hacksaw blade did you use; 18-24-32? Why?
4. When should you use draw filing? Cross filing?
5. Why should files always be fitted with handles.

Evaluation score sheet:

Item	Points	
	Possible	Earned
1. Length of gage	10	_____
2. Width of narrow end	10	_____
3. Width of wide end	10	_____
4. Vee position for cold chisel angle	10	_____
5. Angle for drill cutting edge	15	_____
6. Accuracy of the 1" and 1/2" rules	10	_____
7. Angle for drill lip clearance	10	_____
8. Correct angle and size of bevel corners	5	_____
9. Finish	10	_____
10. Attitude and work habits	10	_____
	100	

Total Points

Gage can be used to measure:

1. Cold chisel cutting angle
2. Twist drill, cutting edge
3. Twist drill, lip clearance

Bill of Material:

1-7/8" x 4-1/16" x 3/32"
aluminum or brass
(aluminum is easier to work)

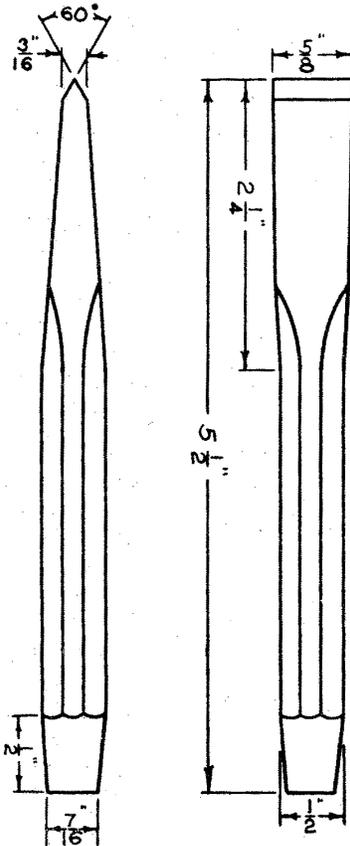
Name _____

Date _____

Grade _____

COLD CHISEL

ORDER NO. 503



Construction Procedure:

1. Heat outer 2-1/4" of stock to a uniform cherry-red color.
2. Place one side against anvil face. Using drawing blows, work to shape rapidly starting at end and work back to 2-1/4" taper.
3. Finish to 3/16" at tip and 5/8" width. Do not work below a dull-red color.
4. Anneal - heat to cherry-red and cool slowly (12-24 hours) in lime or sand.
5. File and polish forged faces - Do not grind.
6. Temper with water: (Practice on old cold chisel).
 - a. heat 2" to 3" of tip to uniform cherry-red color
 - b. cool 3/4" to 1" until drops cling to tip when removed from water
 - c. move tip to avoid cracks at water line
 - d. quickly remove scale with steel brush or file
 - e. observe color changes - quench lower 1/4" on purple color. Color order is light straw, dark straw, brown, purple, dark blue and light blue
7. Grind cutting edge to 60° angle. Use tool gage to check angle.
8. Chamfer end opposite point approximately 1/2" by 7/16" to prevent mushrooming.

Questions:

1. What is the carbon content of tool steel? _____
2. What steel making process is used in making tool steel? _____
3. The color in the color coding system for tool steel is _____.
4. Define annealing _____.
5. At a dull cherry red the temperature in the metal is approximately _____°F.
6. If the color is stopped on light straw the cutting edge will be: a. brittle or b. soft.
7. Define tempering _____.
8. What is the purpose of the chamfer? _____

Bill of Material:

1 - 1/2" x 5" octagon tool steel, .7 - .8 percent carbon content

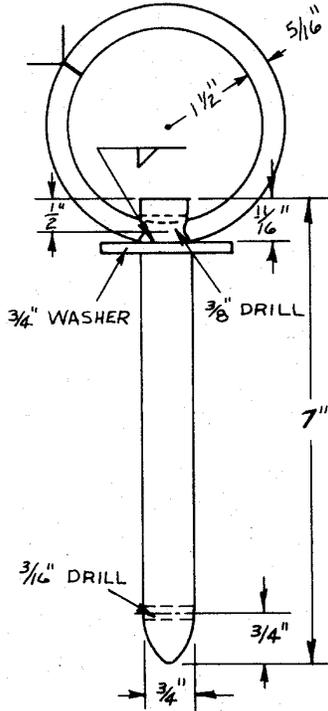
Name _____
 Date _____
 Grade _____

Evaluation Score Sheet:

Item	Points	
	Possible	Earned
1. Correct dimensions		
a. Chisel is 5-1/2" long	10	_____
b. True taper and correct length	10	_____
c. Chamfer dimensions and squareness	10	_____
d. Cutting edge is 5/8" x 3/16"	10	_____
e. Cutting edge ground to 60° - edges even and straight	15	_____
2. Tempering - tip correct hardness	25	_____
3. Overall appearance	10	_____
4. Attitude and work habits	10	_____
Total Points	100	=====

TRACTOR DRAWBAR HITCH PIN

ORDER NO. 504



Operational Procedure:

1. Select and cut material according to plan.
2. Machine: (a) Drill holes for pull ring and safety catch pin. (b) Taper end for easy insertion. (c) Remove oil and oxide if present.
3. Heat Treatment: Suspend TDBHP in molten salt. CAUTION - Do not allow water to contact molten salt - result violent explosion. Allow TDBHP to remain for about 1 to 2 hours, depending upon depth of case desired. Remove and oil quench at end of heat period.
4. Fabrication: Arc weld washer and ring according to plan.

Questions:

1. Spark test before heat treatment.
Low C Medium C High C
2. File test before and after heat treatment TDBHP
Ring and Washer
3. Rockwell hardness on TDBHP test before heat treatment B _____ C _____
4. Rockwell hardness after heat treatment
B _____ C _____
5. How can you visually distinguish hot-rolled from cold-rolled steel?
6. How can you use a piece of angle iron to align holes in round rod or pipe?
7. What tools do you need for locating and marking locations of holes?
8. What drill speed should be used in drilling the holes?
9. What grinding wheel safety precautions should be observed in grinding this pin?
10. How may an arc striking plate be used in welding this pin?

Bill of Material:

- 1 - 5/16" x 10-1/4" M1020 hot rolled round
- 1 - 3/4" flat washer
- 1 - 3/4" x 7" round C1020 cold rolled steel

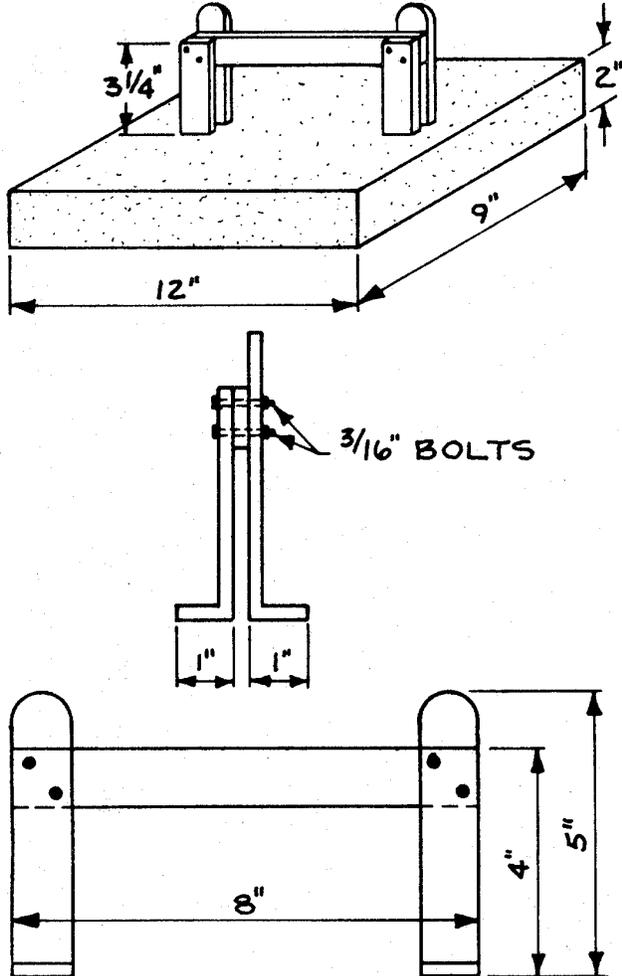
Name _____
Date _____
Grade _____

Evaluation Score Sheet:

Item	Points	
	Possible	Earned
1. Length of pin	5	_____
2. Tapered area smooth	10	_____
3. Washer square to pin	10	_____
4. Washer spaced correctly	10	_____
5. Weld on washer	15	_____
6. Round handle	10	_____
7. Handle centered	10	_____
8. Weld on handle	15	_____
9. Holes centered and aligned	5	_____
10. Attitude and work habits	10	_____
Total Points	100	_____

SHOE SCRAPER WITH CONCRETE BASE

Order No. 540



Construction Procedure:

1. Measure and cut metal pieces.
2. Heat metal, bend legs in vise.
3. Grind leg tops.
4. Mark and center punch holes.
5. Drill holes for 3/16" bolts.
6. Assemble shoe scraper and cut off excess bolts.
7. Construct form for concrete base.
8. Oil forms.
9. Measure dry ingredients and place in mixer.
10. Mix dry ingredients.
11. Measure water, place in mixer and mix concrete.
12. Place concrete in forms about one-half full.
13. Vibrate concrete in mold.
14. Position shoe scraper in mold.
15. Fill mold with concrete.
16. Screed level with surface.
17. Finish with float or trowel.
18. Remove from mold in 24 hours.
19. Place in water tank for 10-14 days.
20. Paint metal shoe scraper.

Construction Teaches: Ability to . . .

1. Measure and cut wood and steel.
2. Heat and bend metal.
3. Drill holes in steel.
4. Assemble the shoe scraper.
5. Construct a form for the concrete base.
6. Measure concrete ingredients.
7. Mix ingredients and cast concrete.
8. Remove concrete from the form.
9. Cure the concrete.
10. Clean and paint the shoe scraper.

Materials:

1. One & one-half quarts grey Portland cement
2. Two & one-half quarts sand
3. Two & one-half quarts small gravel
4. One quart water
5. 30" 1/4" x 1" mild steel strips
6. Four 3/16" x 1" round head stove bolts
7. Exterior plywood pallets, 12" x 15"
8. 1" x 2" x 48" form lumber
9. Five gallon concrete mixer, HoBar M-58
10. Wood float, magnesium float or steel trowel, HoBar No.'s: M-44, M-145 & M-MX-64.
11. Brush, form oil & paint

NAME: _____

DATE: _____ EVALUATION: _____

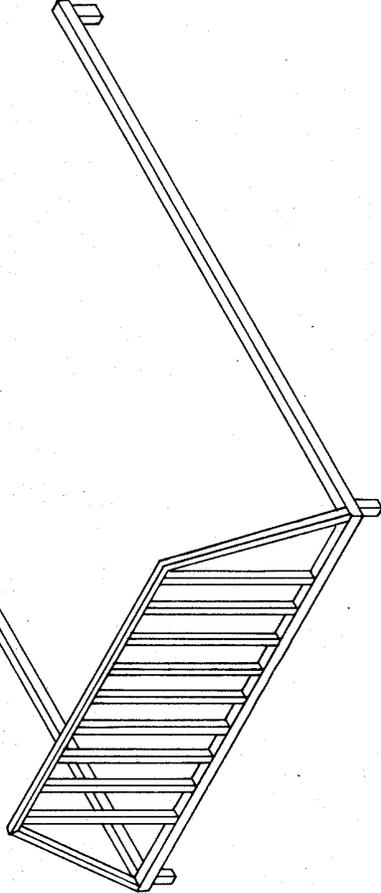
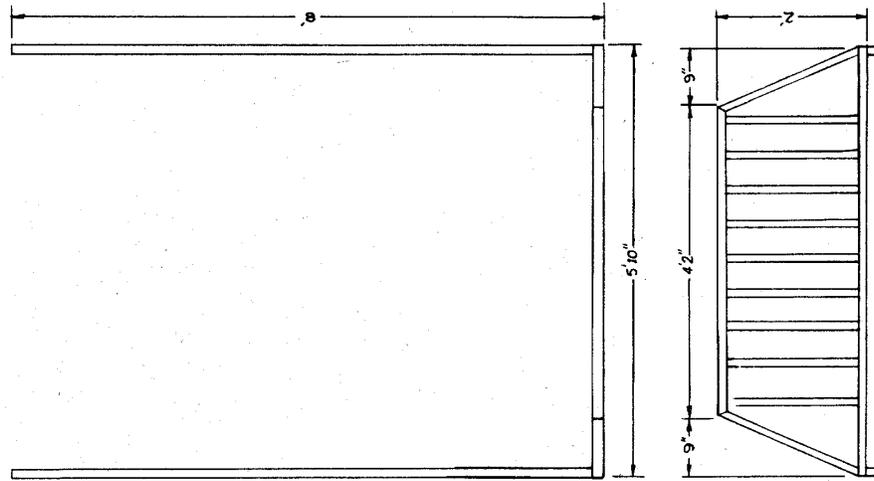
Evaluation Score Sheet:

<u>Item</u>	<u>Possible</u>	<u>Points</u> <u>Earned</u>
1. Dimensions of shoe scraper.	15	_____
2. Dimensions of concrete base	15	_____
3. Location of shoe scraper on base.	10	_____
4. Concrete finish.	20	_____
5. Shoe scraper finish.	20	_____
6. Cleaning of concrete equipment.	10	_____
7. Safety and work habits	10	_____
Total Points	100	_____

02:1

Headache Rack

Scale: $\frac{3}{4}'' = 1'$

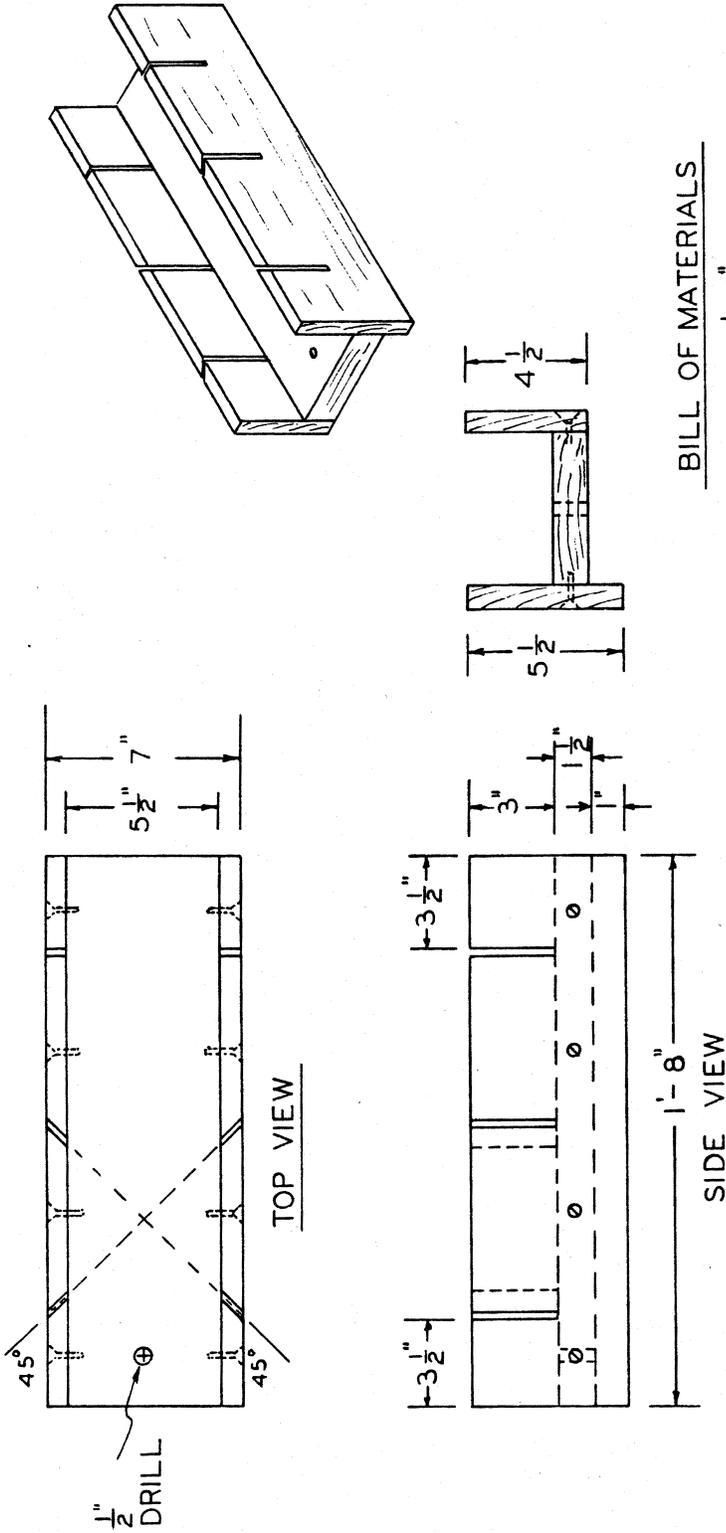


- BILL OF MATERIAL**
- 2 PIECES OF 1½" SQUARE TUBING 8' LONG
 - 1 PIECE OF 1½" SQUARE TUBING 5'10" LONG
 - 9 PIECES OF 1" SQUARE TUBING 1'10" LONG
 - 2 PIECES OF 1" SQUARE TUBING 2'8" LONG
 - 1 PIECE OF 1" SQUARE TUBING 4'2" LONG
 - 4 PIECES OF 1½" SQUARE TUBING 4" LONG

Curriculum and Instructional Materials Center
 State Department of Vocational and Technical Education
 Stillwater, Oklahoma

DRAWN BY: JOHN McEACHERN

Courtesy of Art Neph
 Vocational Agriculture Department



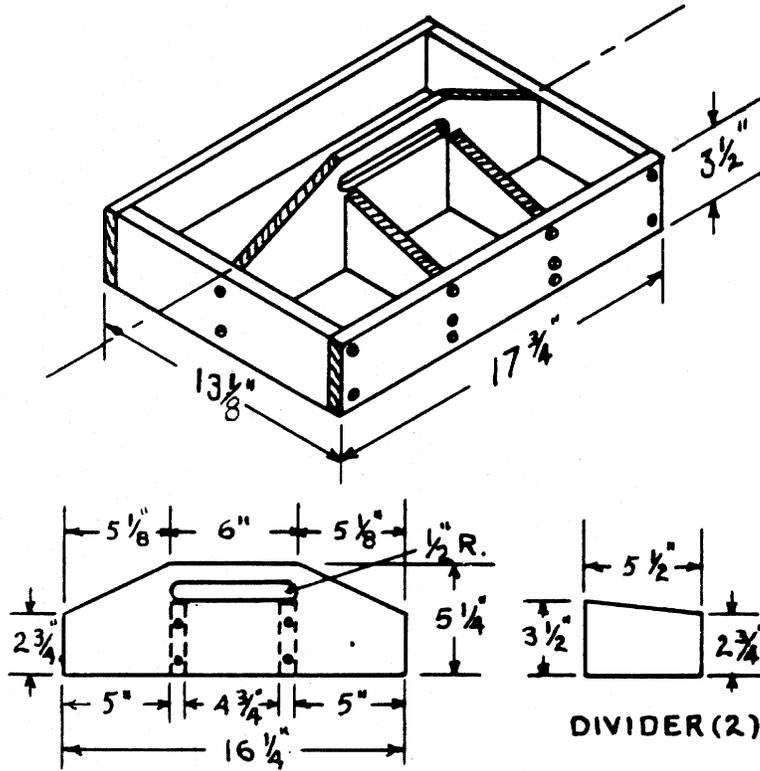
BILL OF MATERIALS

1-	2 X 6 X 1'-8"
1-	1 X 6 X 3'-4"

MITER BOX

NAIL BOX

Order No. 553



Construction Teaches: Ability to . . .

1. Read a plan.
2. Lay out the parts on a board.
3. Select the correct saws.
4. Saw materials to dimension.
5. Select the correct plane.
6. Use the plane.
7. Use a drill to drill pilot, body and countersink holes for screws.
8. Select different types of screws and nails.
9. Drive screws.
10. Select the correct sandpaper.
11. Paint the complete project.
12. Properly clean paint brush and can.

Construction Procedure:

1. Select materials: boards, nails, screws, sandpaper and paint.
2. Lay out the parts.
3. Saw to dimension.
4. Plane to dimension.
5. Sand surfaces.
6. Assemble with finishing nails.
7. Prebore holes for screws.
8. Disassemble and mix glue.
9. Apply glue, assemble with nails and screws.
10. Clean excess glue from joints.
11. Sand and finish joints.
12. Paint.
13. Clean the paint brush and can.

Materials:

1. 1 - 3/4" x 11-5/8" x 16-1/4" - Bottom
2. 2 - 3/4" x 3-1/2" x 11-5/8" - Ends
3. 2 - 3/4" x 3-1/2" x 17-3/4" - Sides
4. 1 - 3/4" x 5-1/2" x 16-1/4" - Handle
5. 2 - 3/4" x 3-1/2" x 5-1/2" - Dividers
6. 26 - 8# x 1-1/2" F.H. Wood Screws
7. 7d Nails.
8. Waterproof or water resistant glue.

NAME: _____

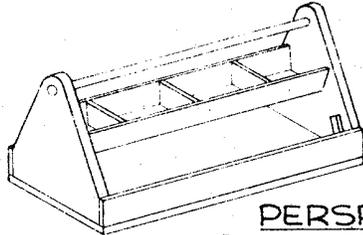
DATE: _____ EVALUATION: _____

Evaluation Score Sheet:

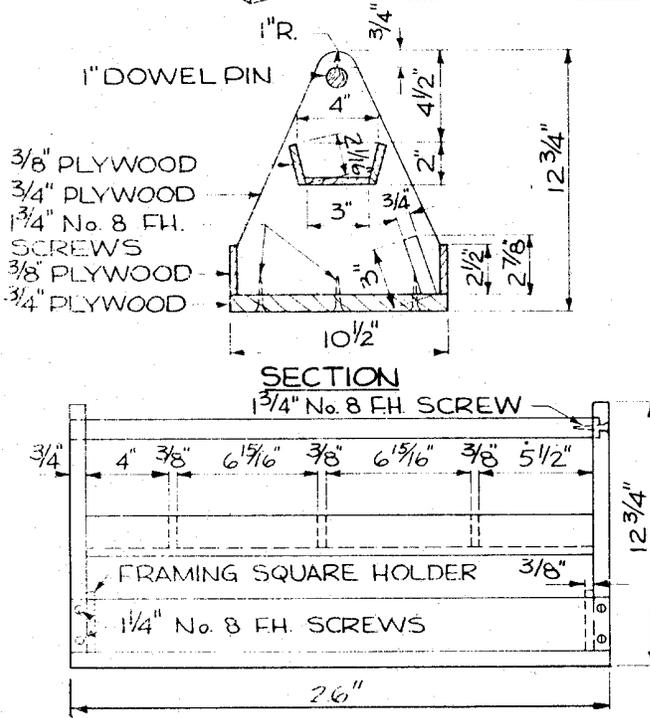
Item	Points	
	Possible	Earned
1. Correct dimensions		
length	5	_____
width	5	_____
height	5	_____
handle	25	_____
dividers	10	_____
2. Square corners & joints.	10	_____
3. Placement of screws. . .	15	_____
4. Paint finish	10	_____
5. Overall appearance . . .	5	_____
6. Attitude and work habits	10	_____
	100	_____

Order No. 554

NAIL & TOOL CARRIER



PERSPECTIVE



Construction Procedure:

1. Lay out material from cutting list.
2. Cut parts to dimension.
3. Bevel edges of bottom of tray.
4. Bore holes for handle in ends.
5. Assemble with small nails to check dimensions.
6. Prebore screw holes.
7. Disassemble and mix glue.
8. Apply glue, assemble with nails and screws.
9. Clean excess glue from joints.
10. Allow glue to set.
11. Sand and finish joints.
12. Paint or varnish.

Construction Teaches: Ability to . . .

1. Read a plan and prepare a cutting list.
2. Measure and mark dimensions.
3. Select correct saw and saw blade.
4. Saw boards to dimension.
5. Use a saber, jig or band saw.
6. Use brace and bit or electric drill and bit.
7. Select correct nails and screws.
8. Select correct wood adhesive.
9. Glue, nail & drive screws during assembly.
10. Sand and finish wood for painting.
11. Select paint or varnish
12. Apply paint or varnish, clean & store brushes.

Materials:

1. 2 - 3/4" x 9-3/4" ends
2. 1 - 3/4" x 10-1/2" x 26" bottom
3. 2 - 3/8" x 2-1/2" x 26" sides
4. 1 - 3/8" x 3" x 24-1/2" tray bottom
5. 2 - 3/8" x 2-1/16" x 24-1/2" tray sides
6. 1 - 3/8" x 2" x 11" tray partition
7. 1 - 1" x 26" dowel pin
8. 2 - 3/8" x 3/4" x 3" framing square holder
9. 8 - 1-1/2" #8 F.H. wood screws (sides)
10. 6 - 1-3/4" #8 F.F. wood screws (ends)
11. Nails, 3d & 7d
12. Exterior plywood or pine boards as desired
13. Waterproof or water resistant glue

Evaluation Score Sheet:

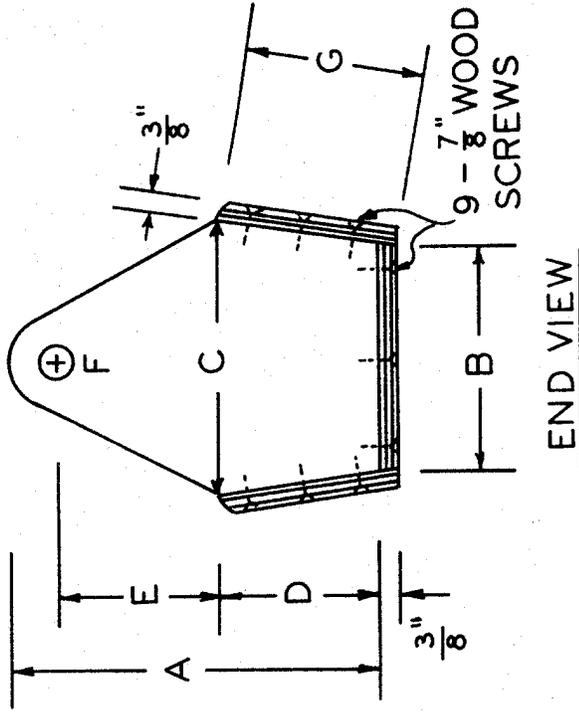
Item	Points	
	Possible	Earned

1. Correct dimensions:		
length	10	_____
width	10	_____
height	10	_____
handle placement . . .	5	_____
tray location	10	_____
2. Square corners & joints	10	_____
3. Edges square and smooth	10	_____
4. Placement of nails and screws	5	_____
5. Finish and painting . .	10	_____
6. Overall appearance . .	10	_____
7. Safety & work habits .	10	_____
Total Points	100	_____

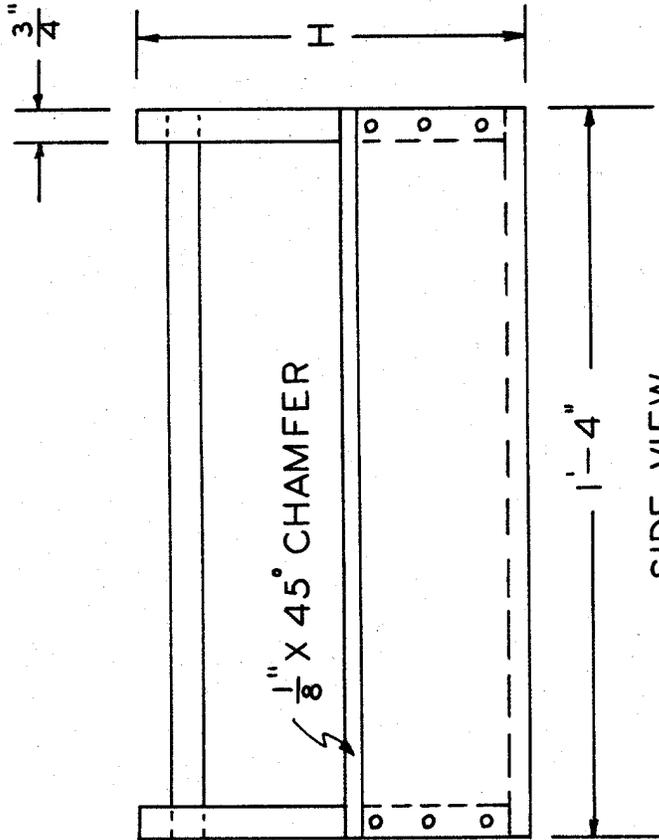
NAME: _____

DATE: _____ EVALUATION: _____

TOOL BOX



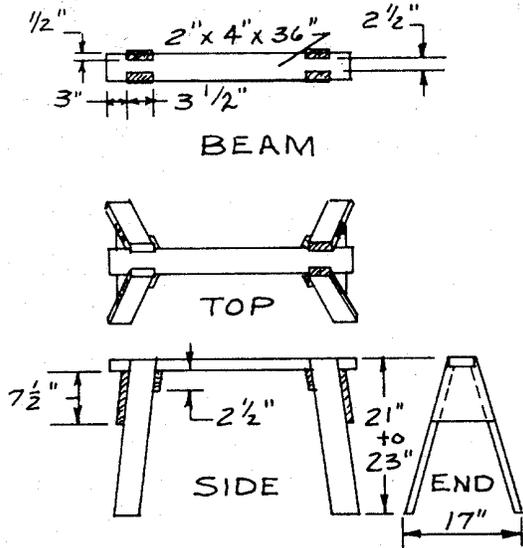
END VIEW



SIDE VIEW

	LARGE	MEDIUM	SMALL
A	12"	9 $\frac{1}{2}$ "	8"
B	7 $\frac{1}{2}$ "	6"	5"
C	9"	7"	6"
D	5"	4"	3 $\frac{1}{2}$ "
E	5 $\frac{3}{4}$ "	4 $\frac{1}{2}$ "	3 $\frac{1}{2}$ "
F	1" DIA.	1" DIA.	1" DIA.
G	5 $\frac{3}{8}$ "	4 $\frac{3}{8}$ "	3 $\frac{7}{8}$ "
H	12 $\frac{3}{8}$ "	9 $\frac{7}{8}$ "	8 $\frac{3}{8}$ "

SAWHORSE



Construction Procedure:

1. Lay out legs and beam with framing square.
2. Cut leg angles and notch beam.
3. Assemble with scaffold nails.
4. Brace legs to desired measurements using temporary braces.
5. Cut permanent leg braces, tack in place.
6. Pre-bore screw holes in legs and braces.
7. Disassemble, apply glue to legs, joints & braces.
8. Assemble with temporary braces.
9. Check measurements with framing square.
10. Insert screws, remove temporary braces.
11. Wipe off excess glue, allow glue to set.
12. Finish with plane or sandpaper and paint.

Construction Teaches:

Ability to

1. Understand correct sawhorse height, spread of leg and beam extension.
2. Lay out edge and side angles of the leg.
3. Determine & lay out total length of leg.
4. Lay out cuts on beam and braces.
5. Saw boards and chisel leg joints on beams.
6. Select correct wood adhesive.
7. Select correct wood screws and nails.
8. Glue, assemble, screw and adjust to desired measurements.
9. Prepare sawhorse for painting.
10. Select and apply paint.
11. Properly clean brushes and painting utensils.

Evaluation Score Sheet:

Item	Points	
	Possible	Earned
1. Dimensions (20)		
Sawhorse height	8	_____
Spread of legs	8	_____
Beam extension	4	_____
2. Angles (28)		
90° beam end to horizontal surface	6	_____
Centerline, equal spread of legs	6	_____
Bevel, bottom of legs	8	_____
All legs on floor	8	_____
3. Joint Preparation		
4 leg joints	12	_____
2 outside braces	6	_____
2 inside braces	6	_____
4. Assembly and Finish		
Screws, nails and glue properly used	10	_____
Finish	8	_____
Safety and work habits	10	_____
Total	100	_____

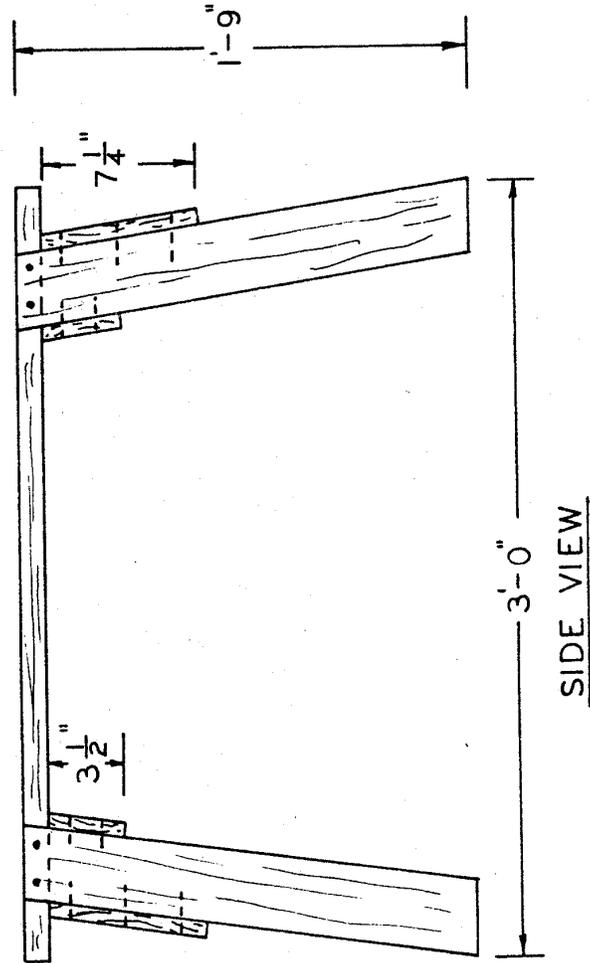
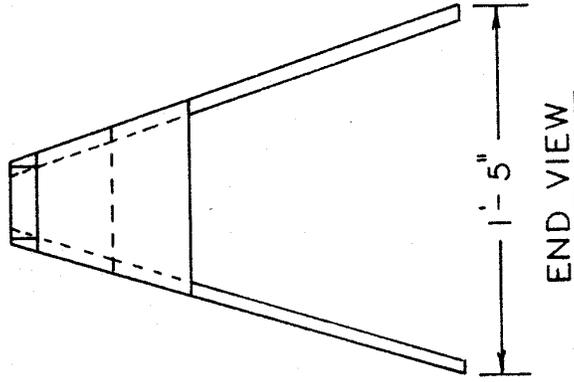
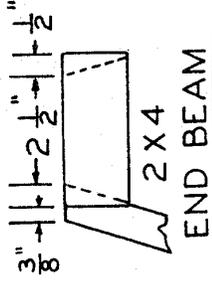
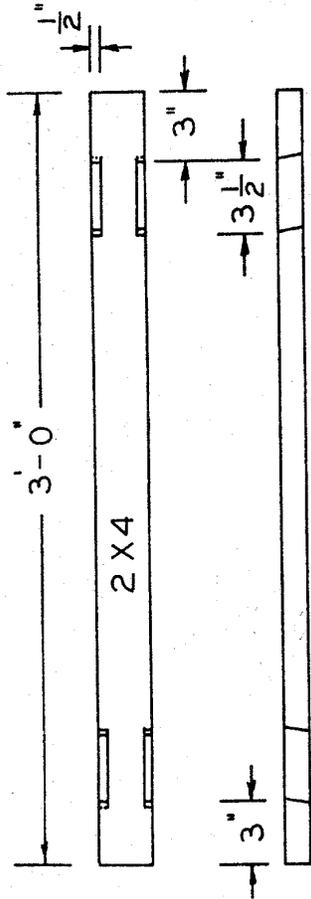
Materials:

1. 1 - 2" x 4" x 3'0" Const. Douglas Fir
2. 1 - 1" x 4" x 9'0" #2 White Pine
3. 1 - 1" x 8" x 2'6" #2 White Pine
4. 24- 1-1/2" 39 Bright F.H. Screws
5. 1 - Pint of paint, desired color
6. 4 oz. of Resorcinol Resin or Casein Glue
7. Sawhorse Layout with the Framing Square, Manual - HoBar #165

NAME: _____

DATE: _____ EVALUATION: _____

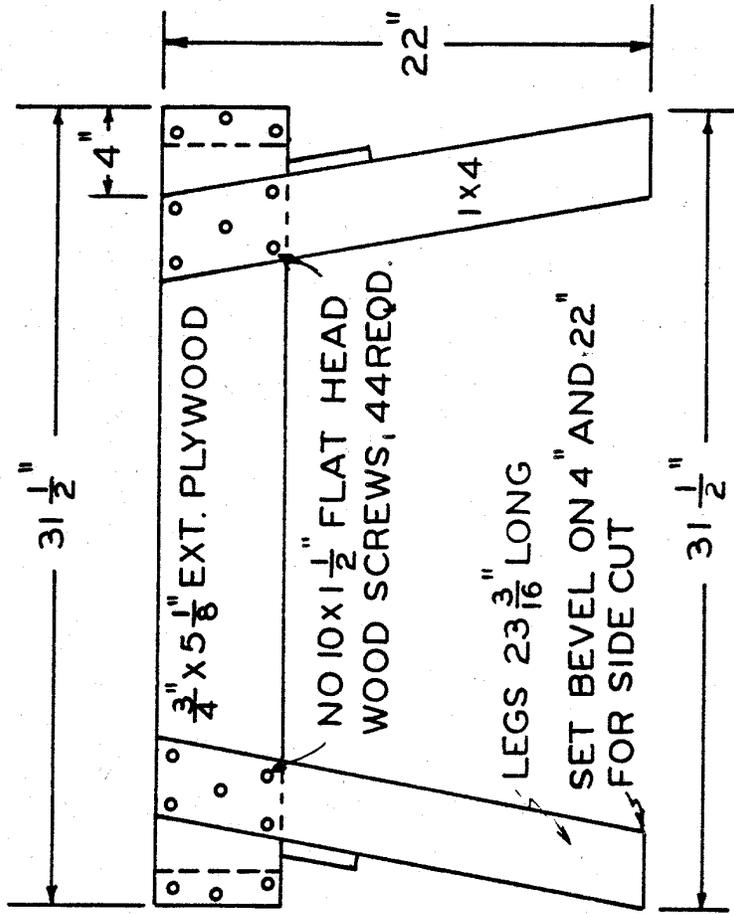
SAWHORSE



- MATERIALS:
- 1 - 2 X 4 X 3'-0" CONST. DOUGLAS FIR
 - 1 - 1 X 4 X 9'-0" # 2 WHITE PINE
 - 1 - 1 X 8 X 1'-8" # 2 WHITE PINE
 - 20 - 7d GALV. BOX NAILS
 - 8 - 1 1/2" # 12 F. H. WOOD SCREWS

BILL OF MATERIAL

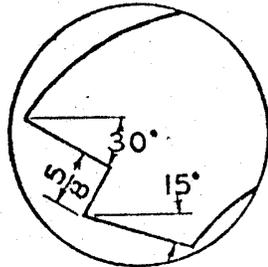
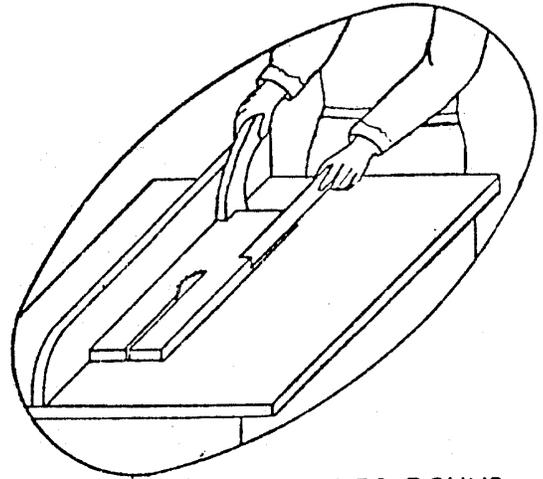
- 2 - $\frac{3}{4}$ " X $5\frac{1}{2}$ " X $31\frac{1}{2}$ " EXT. PLYWOOD
- 1 - 1X4 X 10'-0"



OPEN TOP SAWHORSE



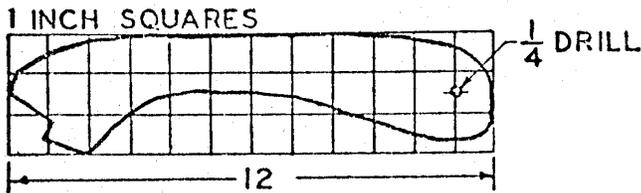
IDEAS FOR AGRICULTURAL MECHANICS SHOPS



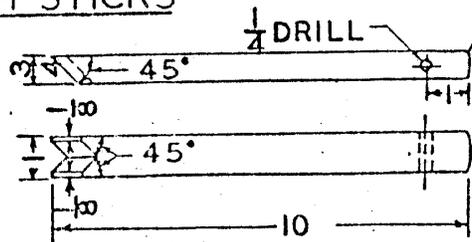
PUSH END DETAIL

SAND EDGES ROUND

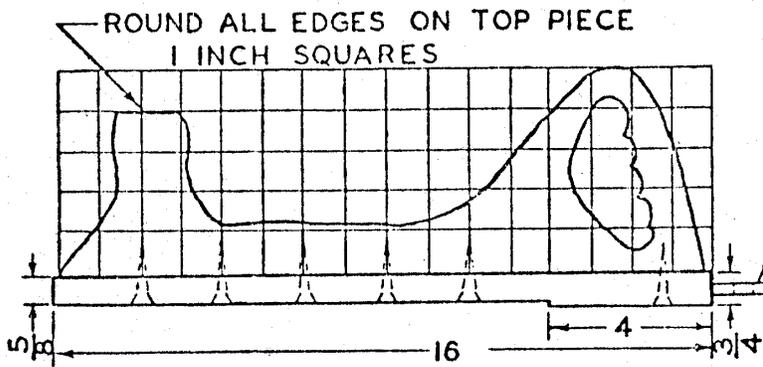
TABLE SAW PUSH STICKS



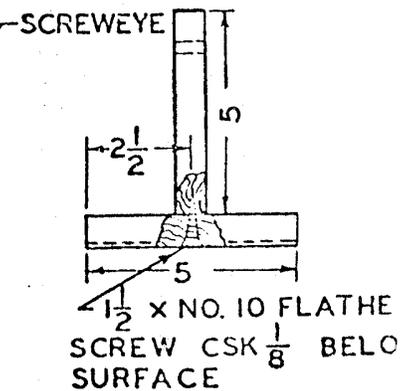
NOTE: ROUND ALL EDGES EXCEPT PUSH END
—RIGHT HAND—



—LEFT HAND—



JOINTER PUSH STICK

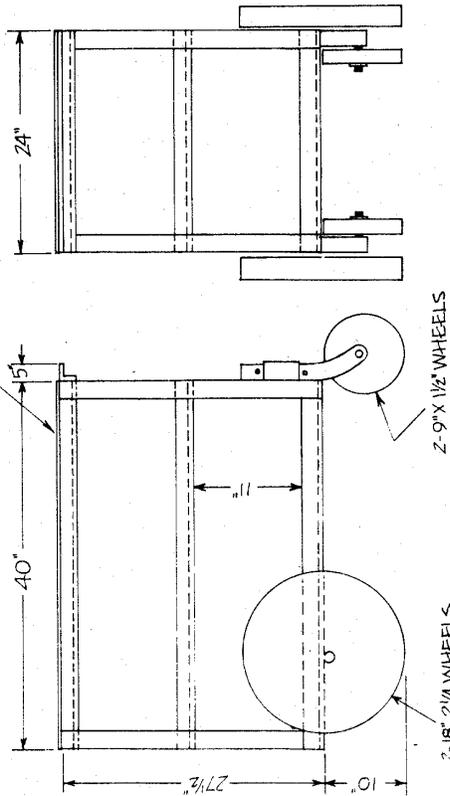


- MATERIALS NEEDED**
- SAW PUSH STICKS
 - 1-3/4X1X10 MAPLE—L. HAND
 - 1-3/4X3X12 MAPLE—R. HAND
 - JOINTER PUSH STICK
 - 2-3/4X5X16 MAPLE
 - 6-1 1/2X NO. 10 FLATHEAD WOOD SCREWS
 - 1-SCREWEYE

Shop Cart

Scale: 3/8"=1"

1/2" PLYWOOD TOPS
40" X 24"



BILL OF MATERIAL
 2" x 2" Angle Iron 41' Long
 1/2" Sucker Rod 4' Long
 1/2" Plywood 30 Square Feet
 4 Metal Wheels

Curriculum and Instructional Materials Center
 State Department of Vocational and Technical Education
 Stillwater, Oklahoma

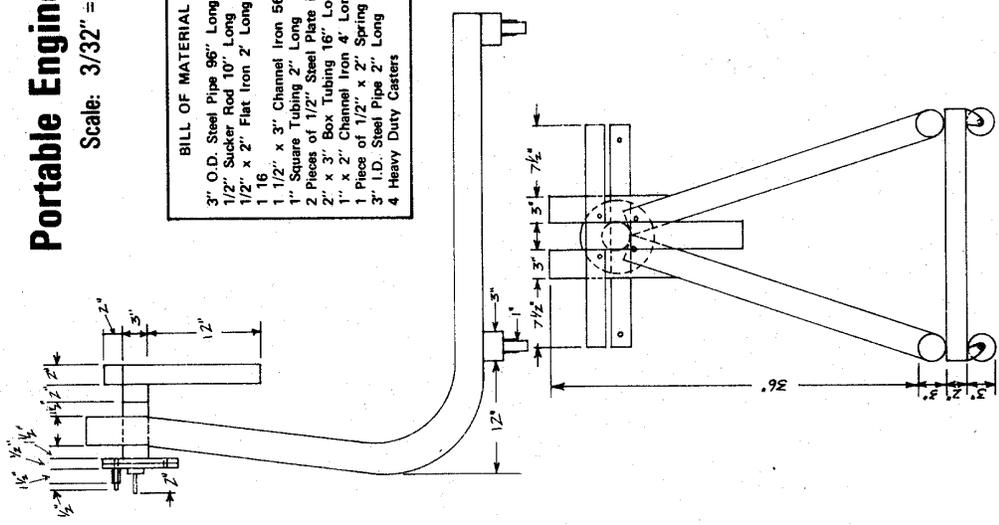
Courtesy of Gubise
 Vocational Agriculture Department

06:2

Portable Engine Stand

Scale: 3/32" = 1"

BILL OF MATERIAL
 3" O.D. Steel Pipe 96" Long
 1/2" Sucker Rod 10" Long
 1/2" x 2" Flat Iron 2' Long
 1 1/8"
 1 1/2" x 3" Channel Iron 56" Long
 1" Square Tubing 2" Long
 2 Pieces of 1/2" Steel Plate in 8" Squares
 2" x 3" Box Tubing 16" Long
 1" x 3" Channel Iron 4' Long
 1 Piece of 1/2" x 2" Spring
 3" I.D. Steel Pipe 2' Long
 4 Heavy Duty Casters



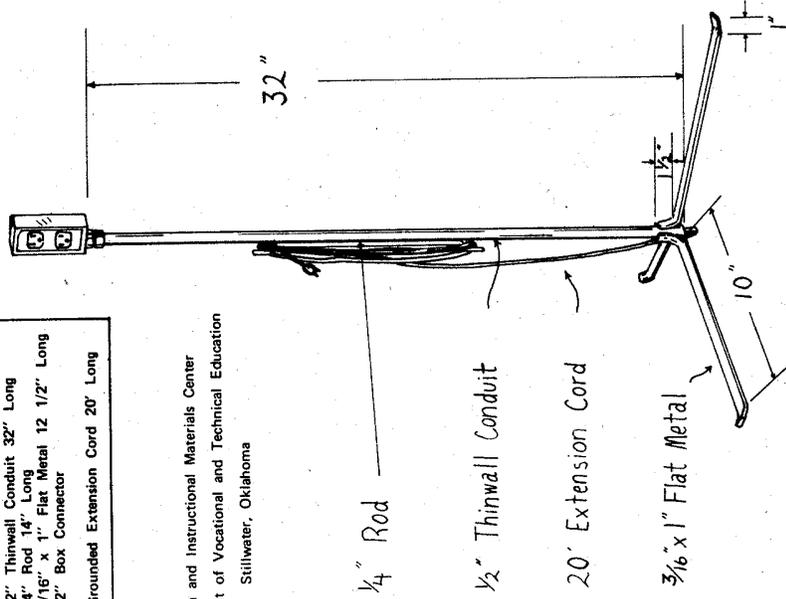
06:3

Portable Extension Outlet

Scale: 3/16" = 1"

- BILL OF MATERIAL**
- 1 Piece of 1/2" Thinwall Conduit 32" Long
 - 1 Piece of 1/4" Rod 14" Long
 - 3 Pieces of 3/16" x 1" Flat Metal 12 1/2" Long
 - 1 Piece of 1/2" Box Connector
 - 1 Handy Box
 - 1 . No. 16 Grounded Extension Cord 20' Long

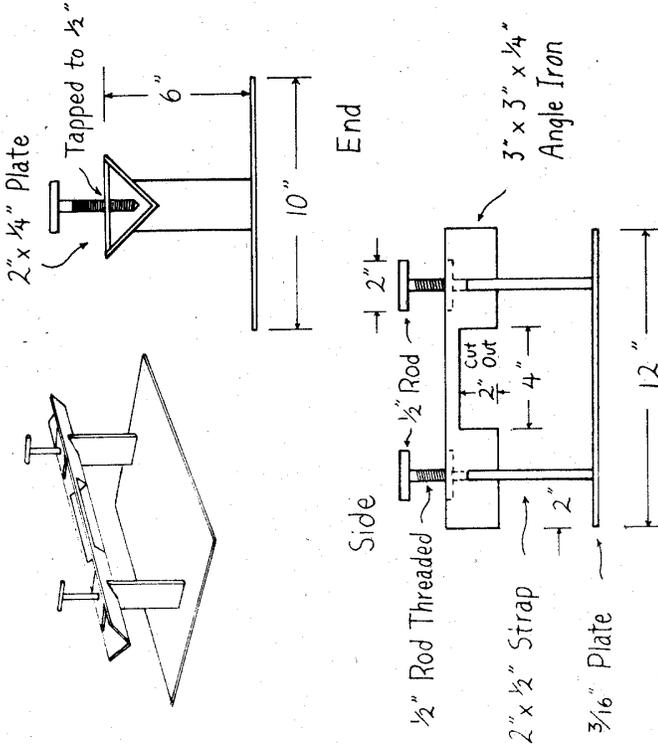
Curriculum and Instructional Materials Center
 State Department of Vocational and Technical Education
 Stillwater, Oklahoma



Round Stock Welding Jig

Scale: 1/4" = 1"

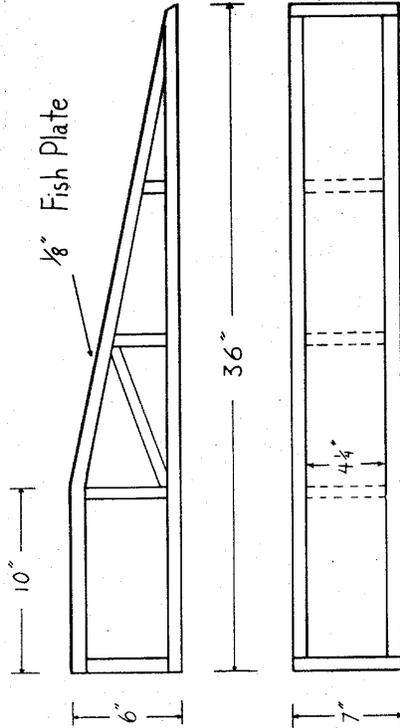
- BILL OF MATERIAL**
- 1 Piece of 3/16" Gauge Metal 10" x 12"
 - 1 Piece of 3" x 3" x 1/4" Angle Iron 12" Long
 - 2 Pieces of 1/2" Strap 2" Wide x 5 1/2" Long
 - 2 Pieces of 1/4" Plate 2" Wide x 3 1/2" Long
 - 2 Pieces of 1/2" Rod 3" Long
 - 2 Pieces of 1/2" Rod 2" Long



Trailer Jack Ramp

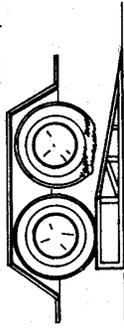
Scale: 3/16"=1"

06:7



- BILL OF MATERIAL**
- 1 Piece of 1/8" Fish Plate 7" X 36"
 - 1 Piece of 3/4" Pipe 18 3/8" Long
 - 3 Pieces of 1 1/4" Pipe 65" Long
 - 4 Pieces of 1" Pipe 14" Long

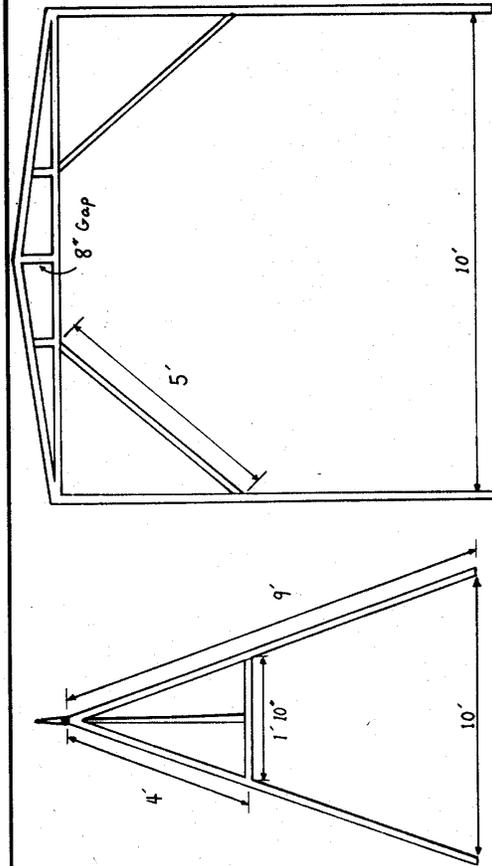
Curriculum and Instructional Materials Center
 State Department of Vocational and Technical Education
 Stillwater, Oklahoma



Courtesy of Carter
 Vocational Agriculture Department

A-Frame

Scale: 1/2"= 1'



- BILL OF MATERIAL**
- 4 Pieces of 2" Pipe 9' Long
 - 1 Piece of 2" Pipe 10' Long
 - 2 Pieces of 2" Pipe 5 1/2" Long
 - 1 Piece of 2" Pipe 8' Long
 - 2 Pieces of 2" Pipe 3' Long
 - 2 Pieces of 2" Pipe 1'10" Long
 - 2 Pieces of 2" Pipe 5' Long

Courtesy of Jett-Nash
 Vocational Agriculture Department

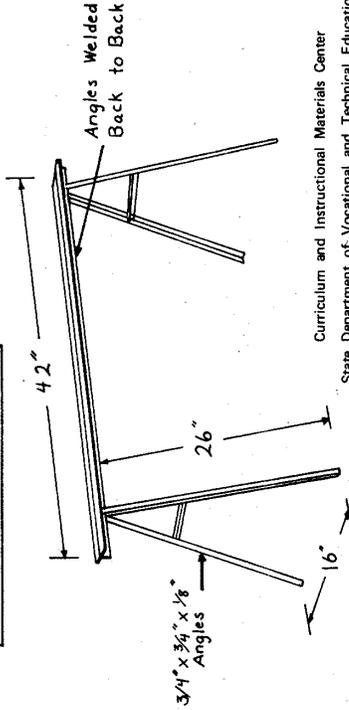
Bob Rea

Angle Iron Saw Horse

06:8

Scale: 3/32"=1"

BILL OF MATERIAL
18' of 3/4" X 3/4" X 1/8" Angle Iron



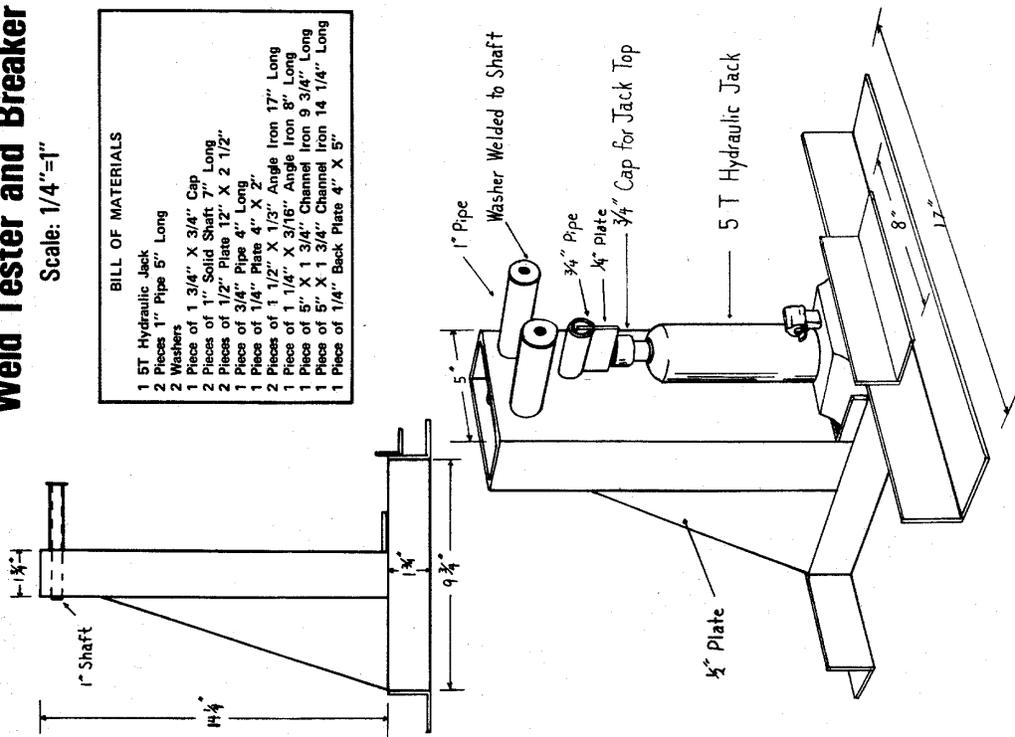
Curriculum and Instructional Materials Center
State Department of Vocational and Technical Education
Stillwater, Oklahoma

Weld Tester and Breaker

Scale: 1/4"=1"

BILL OF MATERIALS

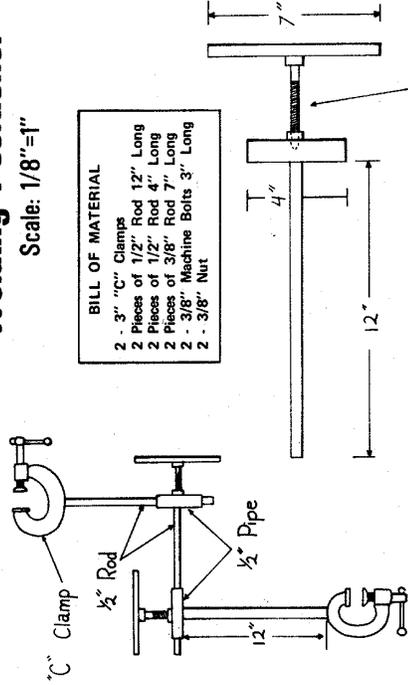
- 1 5T Hydraulic Jack
- 2 Pieces 1" Pipe 5" Long
- 2 Washers
- 1 Piece of 1 3/4" X 3/4" Cap
- 2 Pieces of 1" Solid Shaft 7" Long
- 2 Pieces of 1/2" Pipe 12" X 2 1/2"
- 1 Piece of 3/4" Pipe 4" Long
- 1 Piece of 1/4" Plate 4" X 2"
- 2 Pieces of 1 1/2" X 1 1/3" Angle Iron 17" Long
- 1 Piece of 1 1/4" X 3/16" Angle Iron 8" Long
- 1 Piece of 5" X 1 3/4" Channel Iron 9 3/4" Long
- 1 Piece of 5" X 1 3/4" Channel Iron 14 1/4" Long
- 1 Piece of 1/4" Back Plate 4" X 5"



Welding Positioner

Scale: 1/8"=1"

BILL OF MATERIAL
2 - 3" "C" Clamps
2 Pieces of 1/2" Rod 12" Long
2 Pieces of 1/2" Rod 4" Long
2 - 3/8" Machine Bolts 3" Long
2 - 3/8" Nut

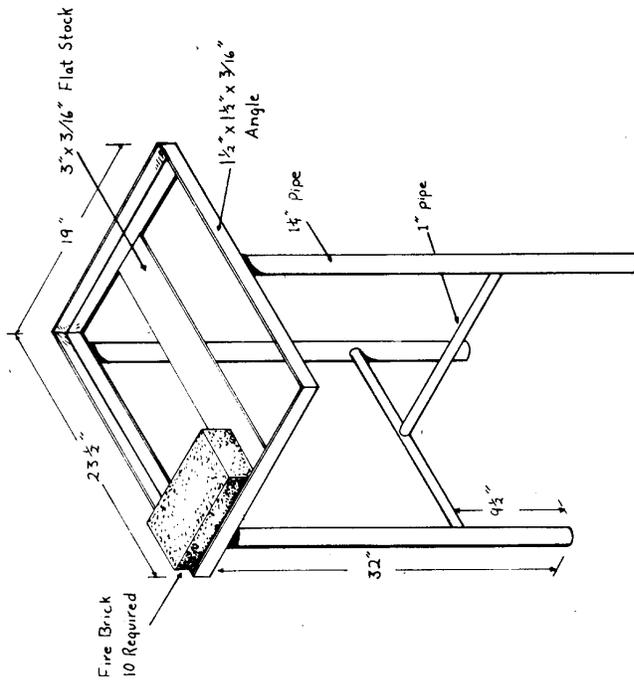


Machine Bolt
Bob Rea

Acetylene Welding Table

Scale: 1/8"=1"

- BILL OF MATERIAL**
- 1 Piece of 3/8" X 1 1/2" X 12" Strap Iron
 - 3 Pieces of 1 1/4" Pipe 32" Long
 - 2 Pieces of 1" Pipe 18" Long
 - 1 Piece of 3" X 3/16" Flat Stock 20 1/2" Long
 - 1 Piece of 2" Pipe 38" Long

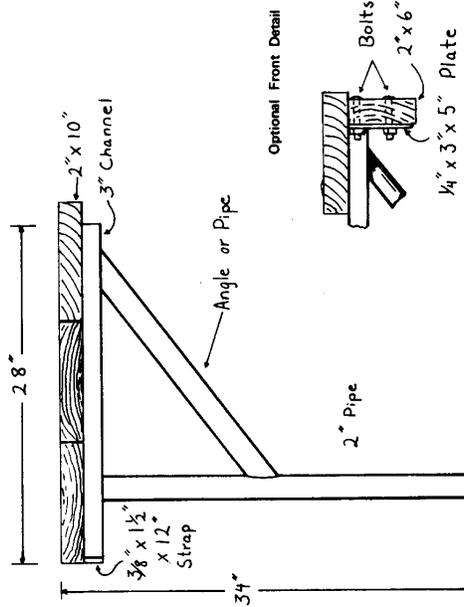
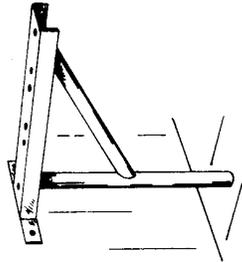


06:9

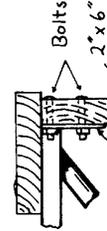
Workbench

Scale: 1/8"=1"

- BILL OF MATERIAL**
- 2 Pieces of 1 1/2" X 3/16" Angle 19" Long
 - 2 Pieces of 1 1/2" X 3/16" Angle 23 1/2" Long
 - 10 Fire Bricks



Optional Front Detail

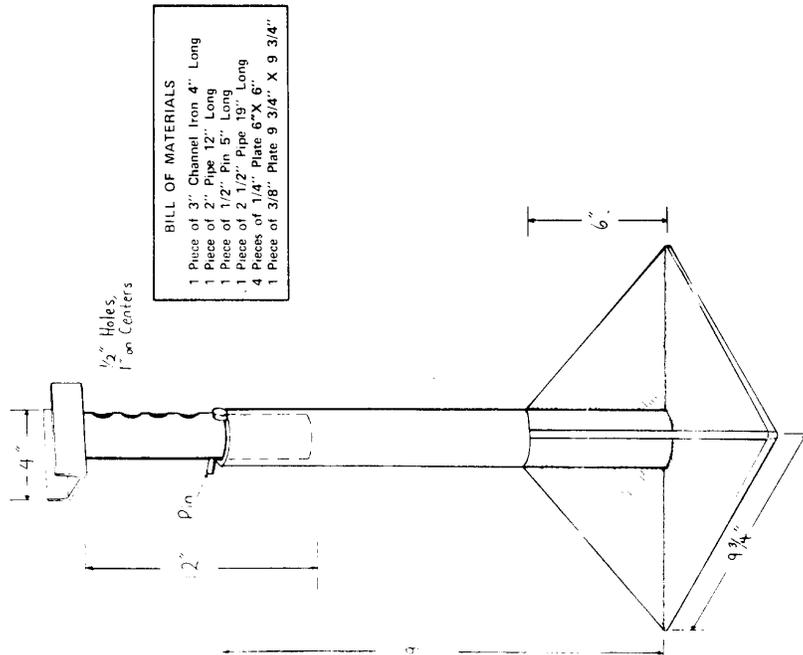


Welded on End

06:10

Adjustable Tractor Holding Jack

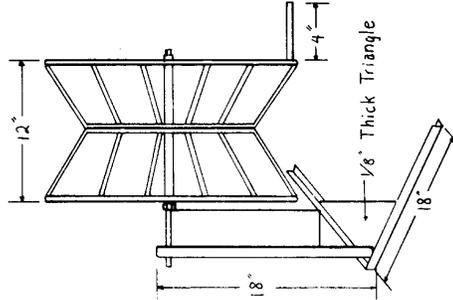
Scale: 1/4"=1"



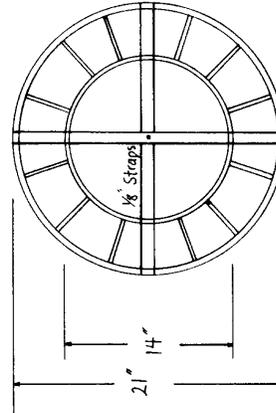
- BILL OF MATERIALS**
- 1 Piece of 3" Channel Iron 4" Long
 - 1 Piece of 2" Pipe 12" Long
 - 1 Piece of 1/2" Pin 5" Long
 - 1 Piece of 2 1/2" Pipe 19" Long
 - 4 Pieces of 1/4" Plate 6" X 6"
 - 1 Piece of 3/8" Plate 9 3/4" X 9 3/4"

Hose Reel

Scale: 1/8"=1"



- BILL OF MATERIALS**
- 2 Pieces of 1" X 1/8" Strap 21" Long
 - 1 Piece of 1/8" Plate 3" X 13"
 - 1 Piece of 3/4" Pipe 18" Long
 - 1 Piece of 3/8" Rod 18" Long
 - 2 Pieces of 3/4" X 1/8" Angle Iron 18" Long
 - 1 Piece of 5/8" Rod 4" Long
 - 1 Piece of 1/2" Pipe 12" Long
 - 1/4" Rod for Rims
 - 3/16" Rod for Spokes
 - 2 Nuts



Curriculum and Instructional Materials Center
 State Department of Vocational and Technical Education
 Stillwater, Oklahoma

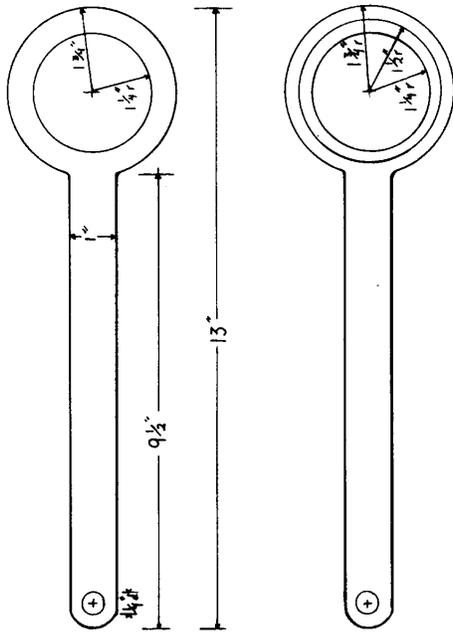
Bob Rea

06:12

Fly Wheel Wrench

Scale: 1" = 1"

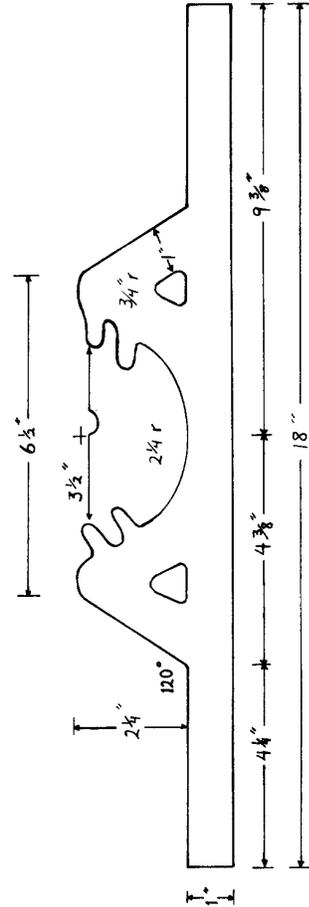
BILL OF MATERIAL
 1 Piece of 5/16" Mild Steel 13" Long
 1 Piece of 3" Pipe Sleeve



Fly Wheel Holder

Scale: 1/2" = 1"

BILL OF MATERIAL
 1 Piece of 5/16" Mild Steel 18" Long



Curriculum and Instructional Materials Center
 State Department of Vocational and Technical Education
 Stillwater, Oklahoma

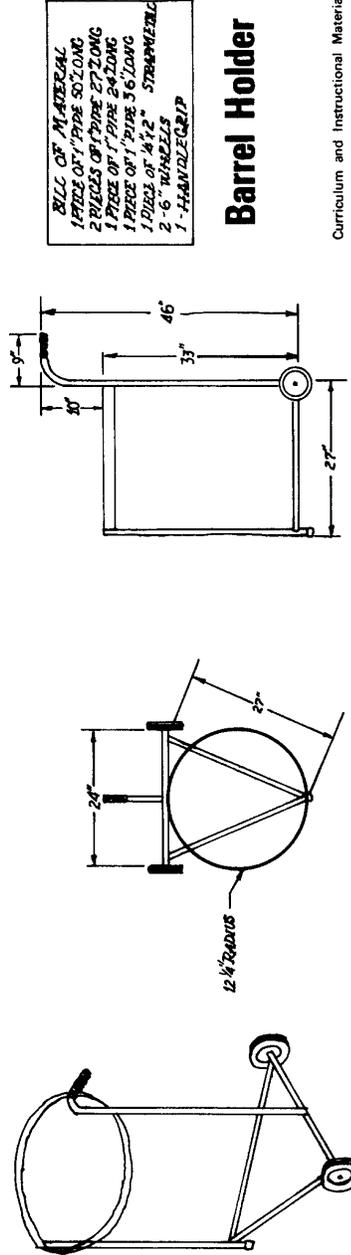
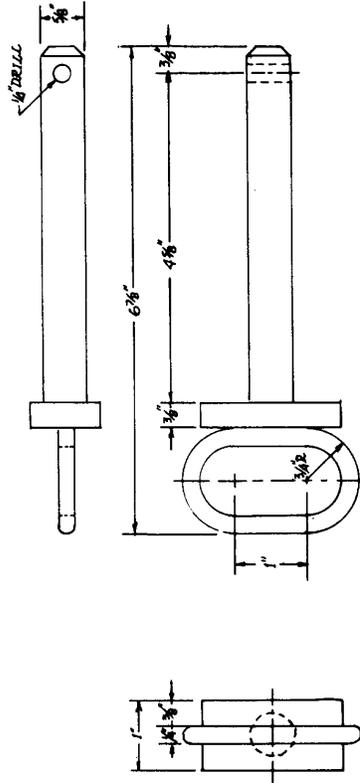
Bob Pea

07:6

BILL OF MATERIALS
 1 PIECE OF $\frac{3}{4}$ " ROD 50" LONG
 1 PIECE OF $\frac{1}{2}$ " PIPE 24" LONG
 1 PIECE OF $\frac{1}{2}$ " PIPE 36" LONG

Drawbar Pin

Scale: $\frac{3}{4}$ " = 1"



BILL OF MATERIALS
 1 PIECE OF PIPE 50" LONG
 2 PIECES OF PIPE 27" LONG
 1 PIECE OF PIPE 36" LONG
 1 PIECE OF $\frac{1}{2}$ " PIPE 36" LONG
 2 - 6" WHEELS
 1 - HANDLE GRIP

Barrel Holder

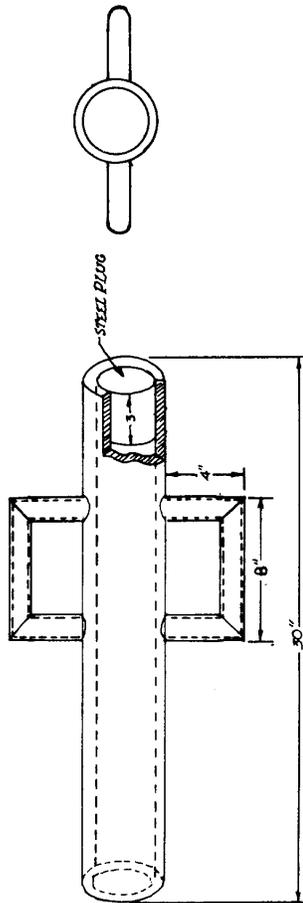
Curriculum and Instructional Materials Center
 State Department of Vocational and Technical Education
 Stillwater, Oklahoma

Courtesy of Keith
 Vocational Department

07:7

Post Driver

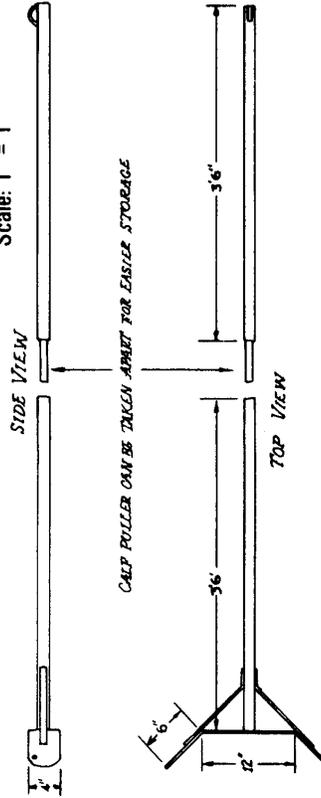
Scale: 3/16" = 1"



BILL OF MATERIALS
 1 PIECE OF 4" PIPE 28" LONG
 2 PIECES OF 1" PIPE 8" LONG
 1 SOLID STEEL PLUG 3" LONG
 4 PIECES OF 1" PIPE 4" LONG

Calf Puller

Scale: 1" = 1'



BILL OF MATERIALS
 2 PIECES OF 1/2" SQUARE TUBING 3' 6" LONG
 2 PIECES OF 1/4" SQUARE TUBING 12" LONG
 1 PIECE OF PLATE METAL 24" x 4" x 3/8"
 2 PIECES OF 1" OR 3/4" STRAP IRON 12" LONG
 1 PIECE OF 3/8" ROD 5" LONG

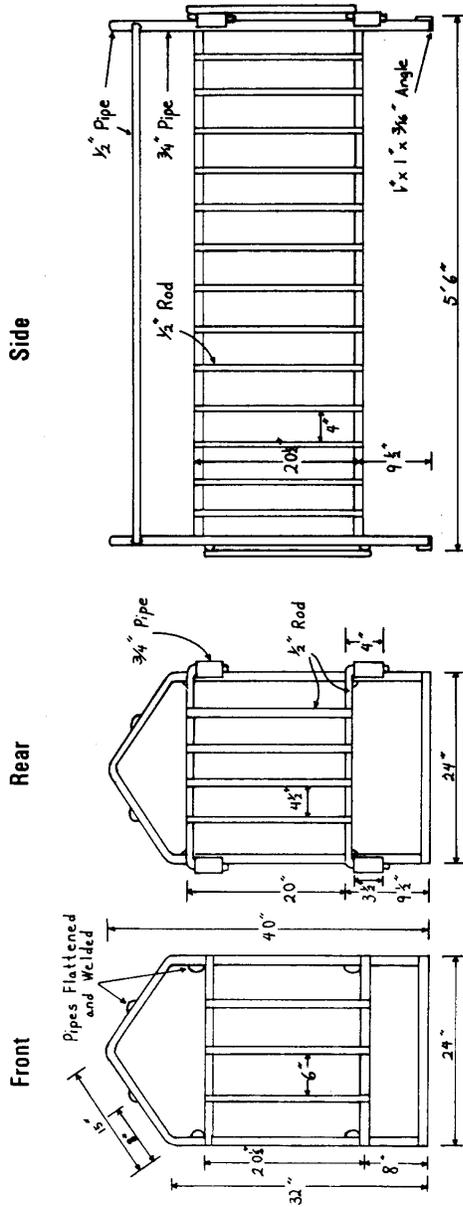
07:9

Farrowing Crate

Scale: 1" = 1'

BILL OF MATERIAL

- 28 Pieces of 1/2" Rod 20 1/2" Long
- 4 Pieces of 1/2" X 1" X 3/16" Angle Iron
- 4 Pieces of 3/4" Pipe 39 1/2" Long
- 4 Pieces of 3/4" Pipe 5'6" Long
- 2 Pieces of 1/2" Rod 24" Long
- 2 Pieces of 1/2" Rod 32" Long
- 4 Pieces of 1/2" Pipe 47" Long

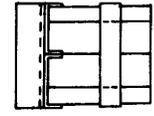
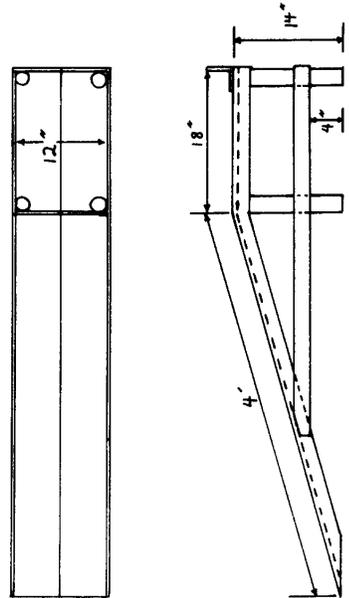


Car Ramp

Scale: 1" = 1'

BILL OF MATERIAL

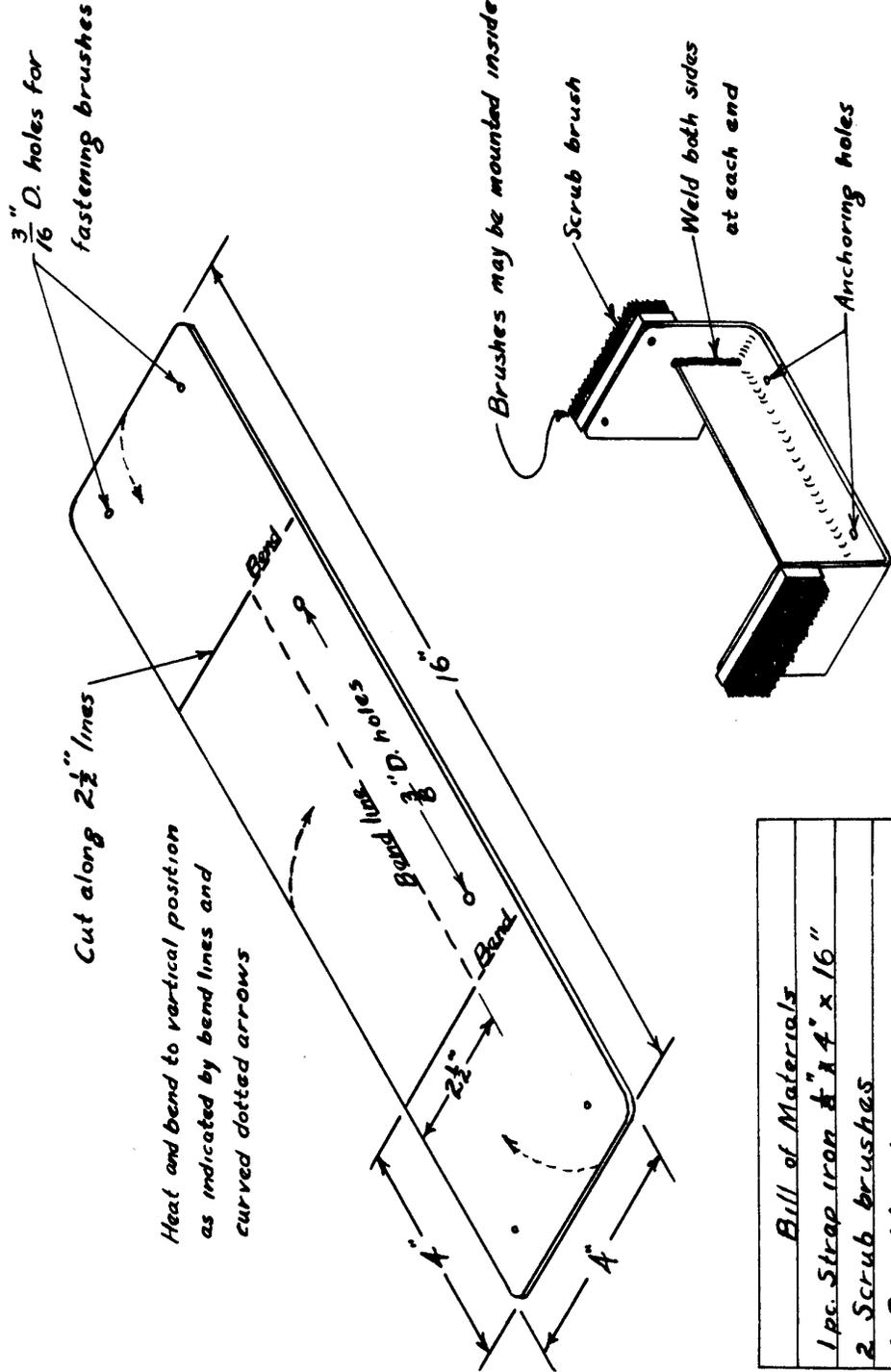
- 2 Pieces of 6" Channel Iron 18" Long
- 2 Pieces of 6" Channel Iron 48" Long
- 4 Pieces of 2" Pipe 14" Long
- 2 Pieces of 1 1/2" Strap Iron 3' Long
- 1 Piece of 1 1/2" Strap Iron 3' Long
- Expand Metal Covering



Curriculum and Instructional Materials Center
 State Department of Vocational and Technical Education
 Stillwater, Oklahoma

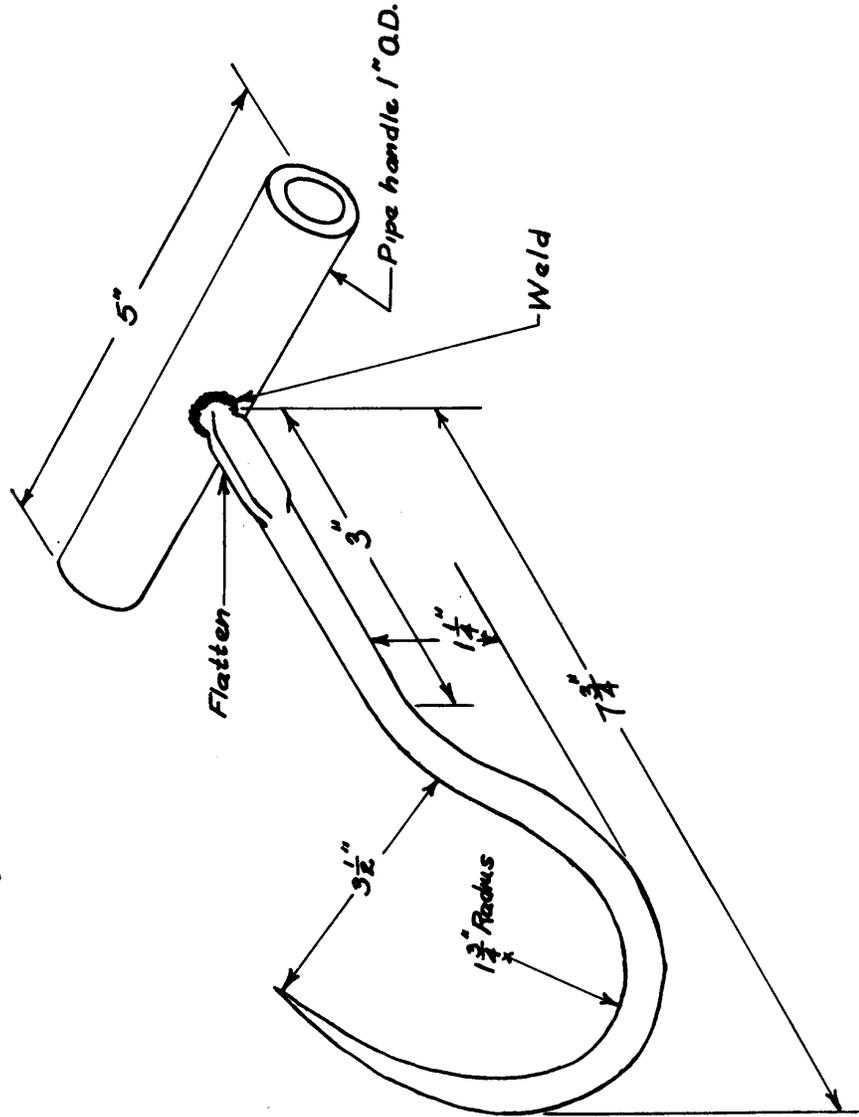
Bob Rea

Shoe Scraper and Cleaner



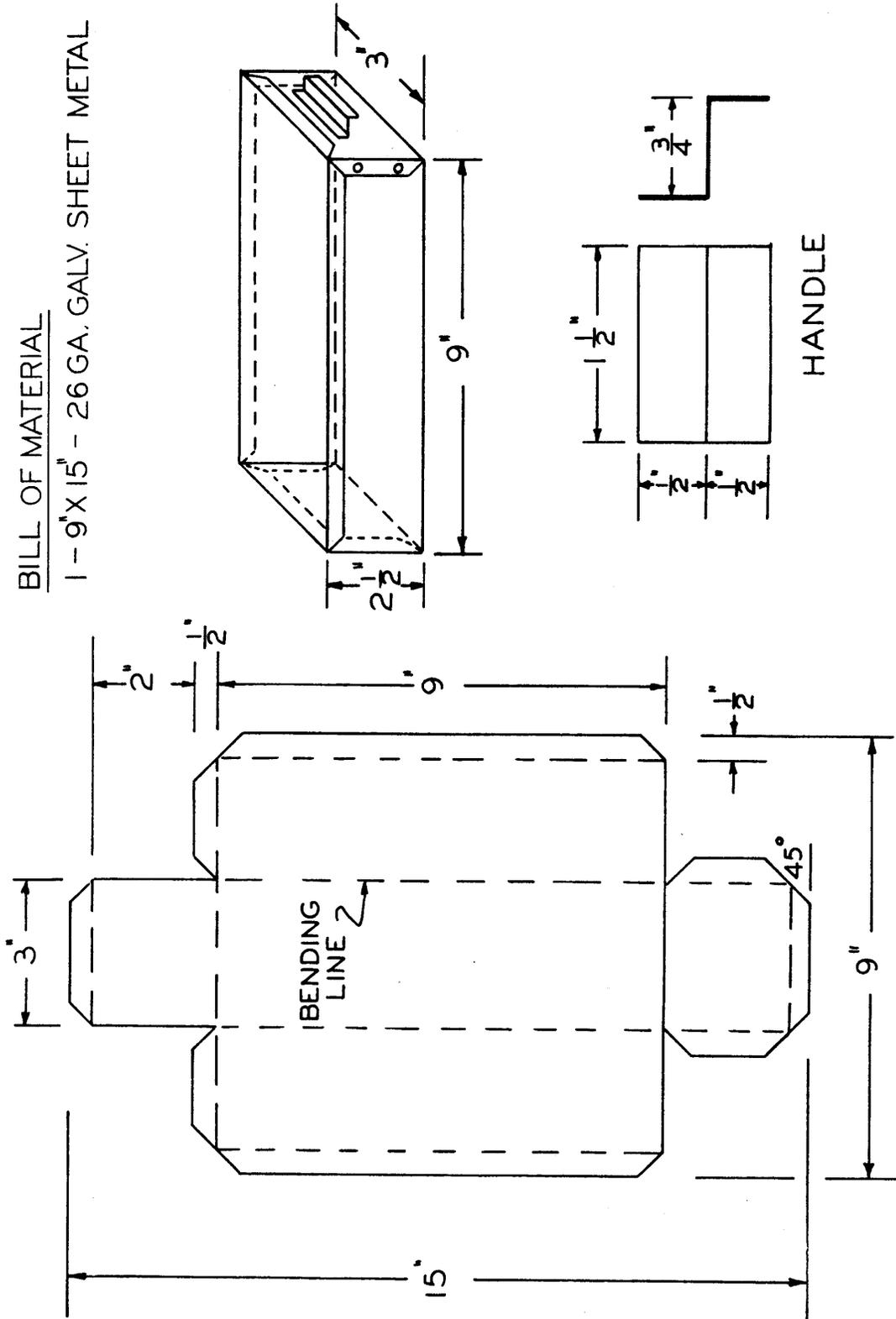
<i>Bill of Materials</i>	
1 pc.	Strip iron 1/4" x 4" x 16"
2	Scrub brushes
4	Round head screws

Hay Hook



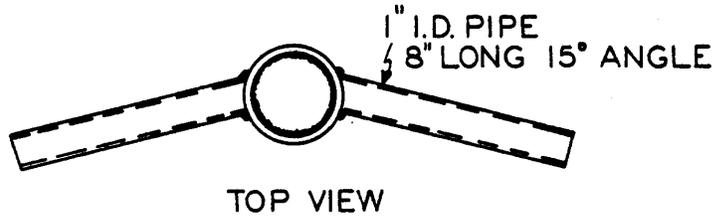
Bill of Materials	
Am't	Item
12"	1/8" Rod
5"	1" Pipe

BILL OF MATERIAL
1 - 9' X 15' - 26 GA. GALV. SHEET METAL

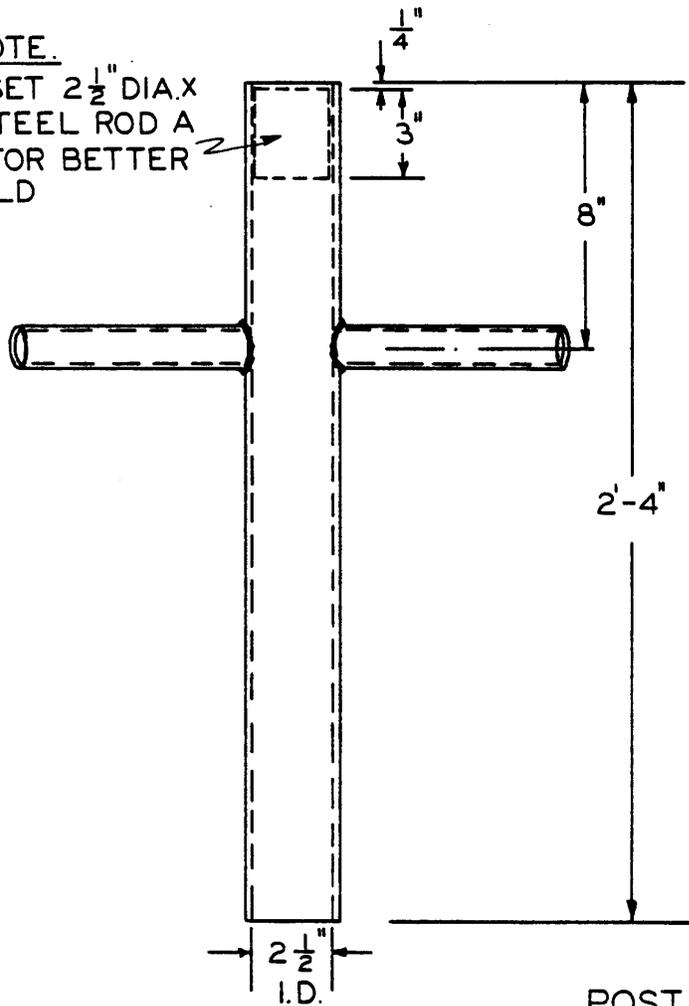


PARTS BOX

CUTTING & BENDING PATTERN
GALVANIZED IRON

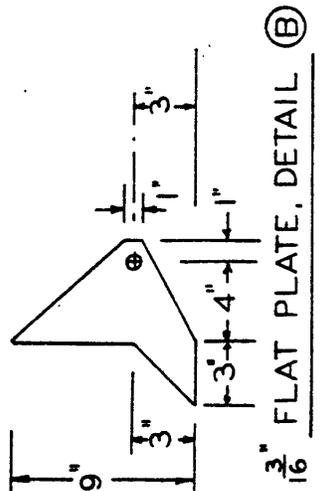
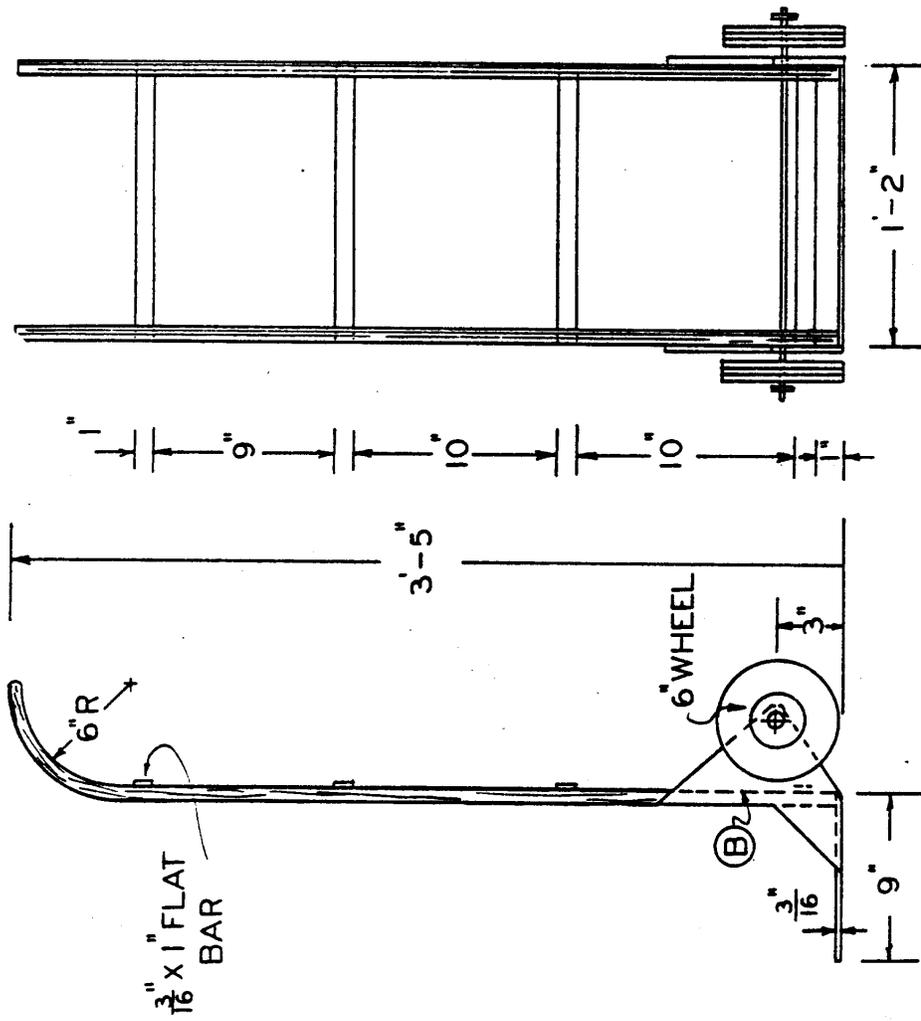


NOTE.
RESET 2½" DIA. X
3" STEEL ROD A
¼" FOR BETTER
WELD



BILL OF MATERIAL
1 - 2½" I.D. X 2'-4" BLACK
PIPE
1 - 1" I.D. X 1'-4" BLACK
PIPE
1 - 2½" DIA. X 3" STEEL ROD

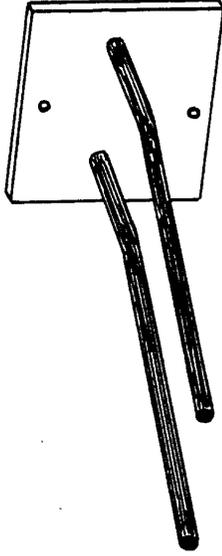
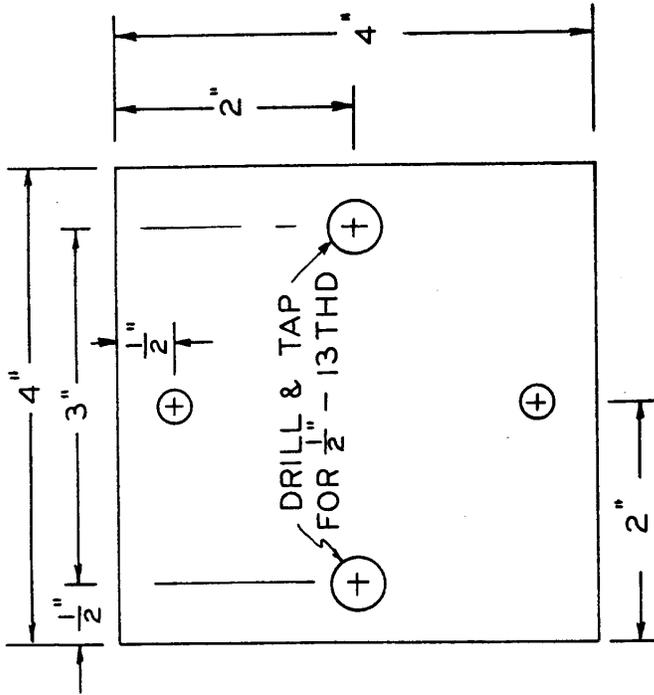
TRANSPORT CART



3/16" FLAT PLATE, DETAIL (B)

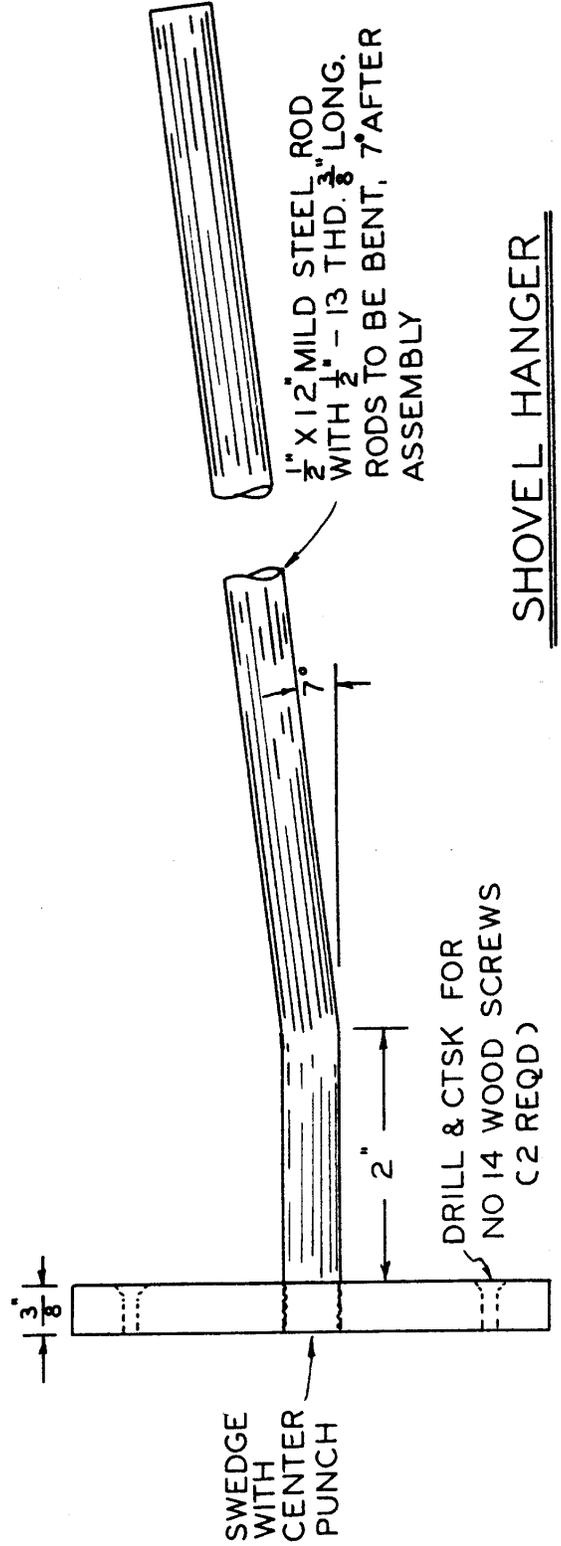
BILL OF MATERIAL

- 3/4" X 8'-0" BLACK PIPE
- 3/16" X 1" X 4'-8" HOT ROLLED FLAT BAR
- 3/16" X 9" X 1'-10" HOT ROLLED PLATE
- 1/2" X 1'-10" COLD ROLLED ROUND
- 2 - 6" HARD RUBBER WHEELS



BILL OF MATERIAL

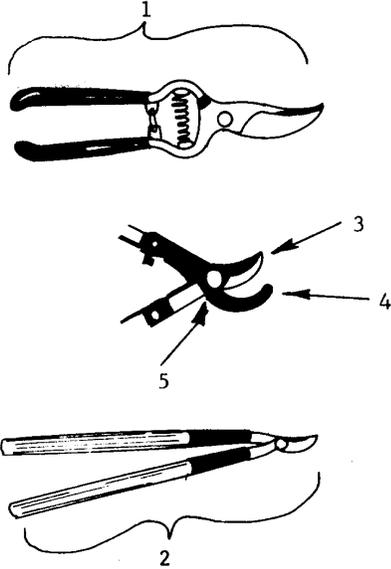
- 1 - 3/8" X 4" X 4" STEEL PLATE
- 1 - 1/2" DIA. X 2'-0" MILD STEEL ROD



SHOVEL HANGER

SHARPENING PRUNING SHEARS WITH CUTTER BARS

Order No. 708



Part Identification:

1. _____ 4. _____
 2. _____ 5. _____
 3. _____

Procedure:

1. Disassemble shears or loppers.
2. Use a round face stone for the cutter bar.
3. Hold the cutter bar at a slight angle to undercut the edge of the bar that contacts the cutting blade.
- 4.hone the flat surface of the cutter bar to remove wire bead.
5. If the cutting blade is nicked, joint it.
6. Hold the cutting blade so the face of the stone rotates into the cutting edge.
7. Grind the desired bevel by moving cutting blade back and forth so as not to overheat any one spot. Use a light pressure against the grinding wheel.
8. After grinding remove the wire bead by honing with a stone. Draw stone across the edge once or twice.
9. Reassemble blades and if they do not continually rub together at point of contact, it may be necessary to slightly spring the cutter bar.
10. Clean and oil lightly.

Operation Teaches: Ability to

1. A. Describe the importance of sharpness in pruning shears.
2. A. Sharpen and undercut cutter bar.
3. A. Joint cutting blade.
4. A. Remove wire bead.
5. A. Adjust pruning shear blades.

Evaluation Score Sheet:

Item	Points	
	Possible	Earned
1. Part identification	15	_____
2. Removal of nicks	15	_____
3. Sharpness of cutting blade	15	_____
4. Angle and uniformity of blade	15	_____
5. Sharpness of cutting bar	15	_____
6. Use of tools	15	_____
7. Safety and work habits	10	_____
Total	100	_____

Materials:

1. Safety glasses
2. Dull pruning shears
3. Bench grinder
4. Oilstone
5. Emery cloth and oil
6. Container of water

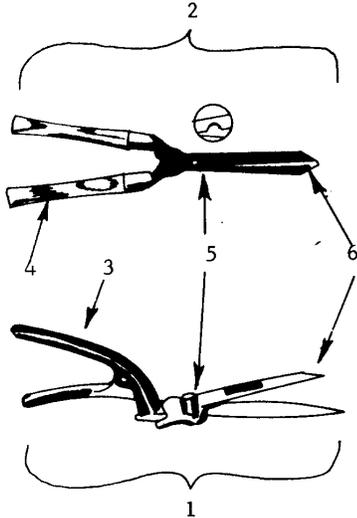
NAME: _____

DATE: _____

GRADE: _____

SHARPENING AND ADJUSTING GRASS AND HEDGE SHEARS

Order No. 707



Part Identification:

- | | |
|----------|----------|
| 1. _____ | 4. _____ |
| 2. _____ | 5. _____ |
| 3. _____ | 6. _____ |

Procedure:

1. Separate blades, open completely, and put one blade in the vise with flat side up and towards you.
2. If nicked or extremely dull, use file. File against edge of blade moving from base to tip. Retain original angle or about 15° to 20° from flat side of blade.
3. Remove wire edge with oilstone by laying stone flat against inside of blade and drawing stone across cutting edge once or twice.
4. Hone bevel until edge appears sharp.
5. Reassemble and tighten screw.
6. Cut a wet paper the full length of the shear. If tearing occurs, hone dull area and test again.
7. Remove rust and dirt with emery cloth and oil.
8. Oil pivot screw and entire length of blades and hang up for safe storage.

Operation Teaches: Ability to

1. A. Describe the types of shears and list their uses.
2. A. Define the importance of properly sharpened tools.
3. A. Use file, stone and vise.
4. A. Properly sharpen a shears.
5. A. Properly adjust a shears.
6. A. Properly oil a shears.
7. A. Properly store a shears.

Evaluation Score Sheet:

Item	Points	
	Possible	Earned
1. Part identification	12	_____
2. Removal of nicks	16	_____
3. Uniformity of bevel	16	_____
4. Tension of blades	16	_____
5. Blades free from rust & dirt	15	_____
6. Use of tools	15	_____
7. Safety and work habits	10	_____
Total	100	_____

Materials:

1. Safety glasses
2. Dull grass or hedge shears
3. File
4. Oilstone
5. Wet newspaper
6. Light oil

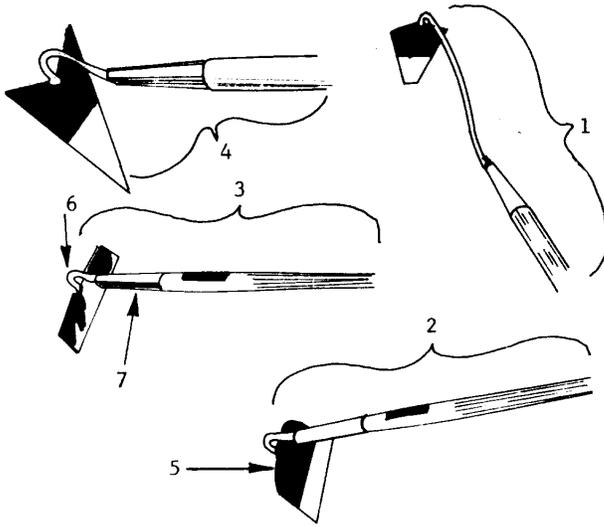
NAME: _____

DATE: _____

GRADE: _____

SHARPENING HOES

Order No. 706



Part Identification:

- 1. _____ 5. _____
- 2. _____ 6. _____
- 3. _____ 7. _____
- 4. _____

Procedure:

1. Inspect cutting edge. Remove nicks with the bench grinder.
2. Clamp shank in vise with handle on floor.
3. File edge on the forward stroke.
4. Hold file at a 45° angle to side of hoe and take long steady strokes along the entire length of the edge.
5. Cutting edge should be filed to 30° angle for ordinary work. A lesser angle if used for cutting weeds.
6. Remove wire edge with a file.
7. Test for sharpness.
8. If rusty, polish with emery cloth and oil.
9. Oil or grease surface of blade.
10. Store out of weather, and where it will not cause injury by falling or hitting people in the area.

Operation Teaches: Ability to

1. A. Define types of hoes and their uses.
2. A. Describe the importance of proper sharpening and storing of hoes.
3. A. Identify different hoes and parts of a hoe.
4. A. Use a bench grinder.
5. A. Use a file and vise.
6. A. Properly sharpen a hoe.
7. A. Maintain a uniform bevel.
8. A. Properly clean and store a hoe.

Evaluation Score Sheet:

Item	Points	
	Possible	Earned
1. Part identification	14	_____
2. Removal of nicks	10	_____
3. Sharpness of blade	20	_____
4. Uniformity of bevel	20	_____
5. Blade free of rust & dirt	15	_____
6. Use of file and vise	10	_____
7. Safety and work habits	11	_____
Total	100	_____

Materials:

1. Safety glasses
2. Hoe
3. Bench grinder
4. Flat file
5. Emery cloth and oil

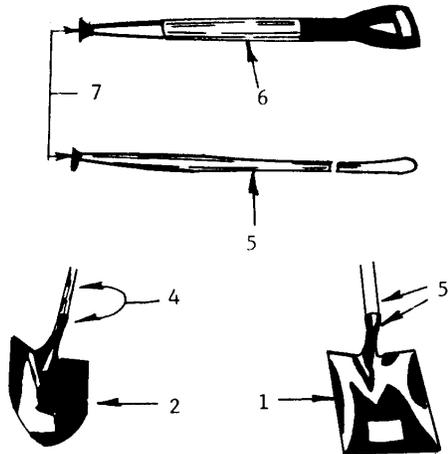
NAME: _____

DATE: _____

GRADE: _____

FITTING A SHOVEL HANDLE

Order No. 705



Part Identification:

- | | |
|----------|----------|
| 1. _____ | 5. _____ |
| 2. _____ | 6. _____ |
| 3. _____ | 7. _____ |
| 4. _____ | |

Procedure:

1. Select a handle that has the correct bend. It is a good practice to take the shovel along when purchasing a new handle.
2. Remove the old handle as follows:
 - a. Place in vise.
 - b. Chisel off the heads of the rivets.
 - c. Drive out old rivets.
 - d. Drill holes into wood remaining in the ferrule.
 - e. Spread the ferrule.
 - f. Drive out old handle.
3. Shape the handle to fit the ferrule by placing it in a vise and using a rasp, file or plane.
4. Drive the handle into place by striking the end of the handle while holding handle and shovel in the air.
5. Be sure the shovel hangs true and does not tilt to the right or left.
6. Drill the hold and drive in first rivet.
7. Hammer the first rivet before drilling holes for other rivets.
8. Insert and secure final rivets.

Operation Teaches: Ability to

- A. Select the correct size and shape of replacement handles.
2. A. Remove old rivets and handle from shovel ferrule.
3. A. Shape wood handle to fit particular ferrule.
4. A. Properly hang a shovel.
5. A. Fit and hammer rivets.

Evaluation Score Sheet:

<u>Item</u>	<u>Points</u>	
	<u>Possible</u>	<u>Earned</u>
1. Part identification	14	_____
2. Selection of handle	15	_____
3. Hang of shovel	15	_____
4. Fit of handle	15	_____
5. Finish of rivets	15	_____
6. Use of tools	15	_____
7. Safety and work habits	11	_____
Total	100	_____

Materials:

1. Safety glasses
2. New handle and rivets
3. Broken shovel
4. Wood rasp and plane

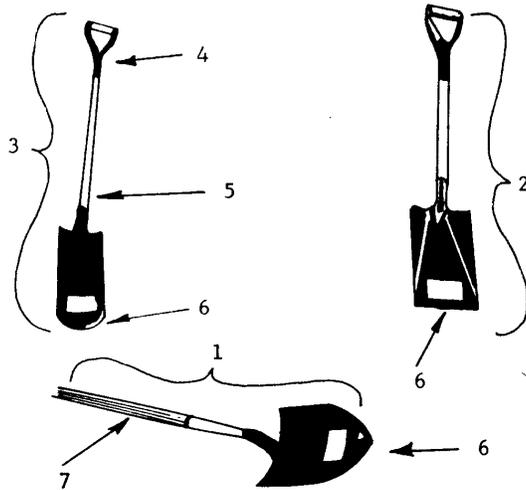
NAME: _____

DATE: _____

GRADE: _____

SHARPENING A SPADE OR SHOVEL

Order No. 704



Part Identification:

- | | |
|----------|----------|
| 1. _____ | 5. _____ |
| 2. _____ | 6. _____ |
| 3. _____ | 7. _____ |
| 4. _____ | |

Procedure:

1. Long heavy-bladed spades and shovels are best sharpened on a bench grinder. Light-weight spades and shovels can be sharpened with a file.
2. Check the spade and shovel blade for disproportionate wear. Joint if necessary.
3. Position spade or shovel to grind on the inside of the blade only.
4. Grind the cutting edge to form a bevel.
5. Keep the blade moving steadily back and forth across the wheel. Do not use excessive pressure.
6. Dip the blade into water to prevent overheating. Overheating destroys the temper in the metal.
7. Removal of the wire bead is not necessary but can be done if desired with a flat file.
8. Clean and polish with steel wool or emery cloth. Apply a light coat of oil.

Operation Teaches: Ability to

- 1 A. Outline the importance of a properly sharpened spade or shovel.
- 2 A. Select the correct procedure for sharpening a spade or shovel.
- 3 A. Joint an out-of-shape spade or shovel.
- 4 A. Grind a bevel on a spade or shovel.
- 5 A. Sharpen without losing the temper from the blade of a spade or shovel.
- 6 A. Clean and store a spade or shovel.

Evaluation Score Sheet:

Item	<u>Points</u>	
	<u>Possible</u>	<u>Earned</u>
1. Part identification	14	_____
2. Proper shape of blade	15	_____
3. Sharpness of blade	15	_____
4. Evidence of overheating	15	_____
5. Degree and uniformity of bevel	15	_____
6. Use of tools	15	_____
7. Safety and work habits	<u>11</u>	_____
Total	100	_____

Materials:

1. Safety glasses
2. Bench grinder
3. Dull spade or shovel
4. File
5. Steel wool or emery cloth and oil
6. Container of water

NAME: _____

DATE: _____

GRADE: _____

SHARPENING AN AX OR HATCHET

Order No. 703

	<p><u>Part Identification:</u></p> <p>1. _____ 4. _____</p> <p>2. _____ 5. _____</p> <p>3. _____ 6. _____</p> <hr/> <p><u>Procedures:</u></p> <ol style="list-style-type: none"> 1. Inspect the edge. Determine the amount of grinding necessary. 2. Check the balance. Place cutting edge and handle on flat surface. The blade should touch the surface about 2/3 of the way from the fore edge of the blade. 3. If blade is out of balance it may be jointed. Joint by laying the blade flat on the tool rest and pointed towards the grinding stone. 4. Grind the fan-shaped bevel. This will be much higher on a cutting ax than a splitting ax. 5. Grind the short bevel on each side of the cutting edge. The grinding wheel turns towards the cutting edge to prevent forming a wire edge. Prevent overheating by using light pressure and cooling the ax in water. 6. Hone the edge with an oilstone. The ax is held in one hand and stone moved with the other hand. 																													
<p><u>Operation Teaches:</u> Ability to . . .</p> <ol style="list-style-type: none"> 1. A. Describe the difference between a cutting and splitting ax and between hatchets. 2. A. Balance an ax. 3. A. Joint an ax. 4. A. Grind fan-shaped bevel. 5. A. Grind short bevel. 6. A. Hone the edges with an oilstone. 	<p><u>Materials:</u></p> <ol style="list-style-type: none"> 1. Safety glasses 2. Bench grinder 3. Oilstone 4. Dull ax or hatchet 5. Container of water 																													
<p><u>Evaluation Score Sheet:</u></p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2" style="text-align: left; width: 60%;">Item</th> <th colspan="2" style="text-align: center; border-bottom: 1px solid black;">Points</th> </tr> <tr> <th style="text-align: center; border-bottom: 1px solid black;">Possible</th> <th style="text-align: center; border-bottom: 1px solid black;">Earned</th> </tr> </thead> <tbody> <tr> <td>1. Part identification</td> <td style="text-align: center;">12</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>2. Removal of nicks</td> <td style="text-align: center;">10</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>3. Sharpness of blade</td> <td style="text-align: center;">30</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>4. Uniformity of bevel</td> <td style="text-align: center;">15</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>5. Balance of ax</td> <td style="text-align: center;">15</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>6. Use of grinder & stone</td> <td style="text-align: center;">10</td> <td style="text-align: center;">_____</td> </tr> <tr> <td>7. Safety & work habits</td> <td style="text-align: center;">8</td> <td style="text-align: center;">_____</td> </tr> <tr> <td style="text-align: right;">Total</td> <td style="text-align: center;">100</td> <td style="text-align: center;">_____</td> </tr> </tbody> </table>	Item	Points		Possible	Earned	1. Part identification	12	_____	2. Removal of nicks	10	_____	3. Sharpness of blade	30	_____	4. Uniformity of bevel	15	_____	5. Balance of ax	15	_____	6. Use of grinder & stone	10	_____	7. Safety & work habits	8	_____	Total	100	_____	<p>NAME: _____</p> <p>DATE: _____</p> <p>GRADE: _____</p>
Item		Points																												
	Possible	Earned																												
1. Part identification	12	_____																												
2. Removal of nicks	10	_____																												
3. Sharpness of blade	30	_____																												
4. Uniformity of bevel	15	_____																												
5. Balance of ax	15	_____																												
6. Use of grinder & stone	10	_____																												
7. Safety & work habits	8	_____																												
Total	100	_____																												

SHARPENING A KNIFE

Order No. 702



Pruning Knife



Grafting Knife

Procedure:

1. Inspect the blade to determine its condition. If nicked, it needs to be ground or dressed on a grinding wheel.
2. Grind the blade: Hold the blade flat on the surface of the wheel. The blade should be held so that the wheel turns into the cutting edge. Caution! Press very lightly on the blade while grinding. Dip the blade in cold water frequently to prevent it from becoming overheated resulting in a loss of temper. The metal in the thin blade burns quickly if too much pressure is used.
3. Hone the blade on an oilstone. Oil the stone and lay the blade flat on the stone and move it over the surface toward the cutting edge. Lift the blade at the end of each stroke; turn it over and hone the other side on the return stroke.
4. Test for sharpness: Wipe off the oil with a cloth and test the blade by running thumb lightly along the edge. If it feels smooth, yet pulls a little, it is sharp. Be sure that it is sharp along the entire length.
5. Strop the edge on the smooth surface of a piece of leather. This is not necessary unless an especially keen edge is desired. In stropping, move the blade over the leather away from the cutting edge.

Operation Teaches: Ability to

- A. Discuss the value of a sharp pruning knife.
2. A. Inspect a blade.
3. A. Grind a blade.
4. A. Hone with an oilstone.
5. A. Test for sharpness.
6. A. Strop the edge of a knife.

Evaluation Score Sheet:

<u>Item</u>	<u>Points</u>	
	<u>Possible</u>	<u>Earned</u>
1. Removal of nicks	15	_____
2. Angle of bevel	15	_____
3. Uniformity of bevel	15	_____
4. Sharpness of blade	30	_____
5. Use of tools	15	_____
6. Safety and work habits	10	_____
Total	100	_____

Materials:

1. Safety glasses
2. Dull pruning knife
3. Fine grained grinding wheel
4. Oilstone
5. Stropping leather
6. Light weight oil
7. Container of water

NAME: _____

DATE: _____

GRADE: _____